1984 AND 1985
HAMILTON AIR QUALITY

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West Central Region

1984 AND 1985 HAMILTON AIR QUALITY

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1. SUMMARY

Air quality in Hamilton in 1984 and 1985 showed variable trends for the various pollutants monitored.

The Air Pollution Index reached the advisory level of 32 only twice in 1985 compared to 9 occasions in 1984.

The network of high volume samplers measuring suspended particulates generally showed slightly higher levels in 1984 than in the previous year, but then reduced substantially in most parts of the City in 1985.

Dustfall jars located throughout the city to measure heavy settleable dust, showed no significant change from previous years and remained well above objectives in the industrial and central area of the city.

For fine particulate measurements known as soiling index, data strongly indicated that the source of this measurement was related mainly to vehicle traffic rather than industrial sources.

The network of fluoride monitors indicated progressively lower concentrations during 1984 and 1985 especially in the industrial area.

Gaseous pollutants monitored at the two main stations showed little change. Ozone is one of two gases which continued to exceed criteria. It is a product of long range transport and is produced photochemically to excess during the summer. The other problem pollutants are reduced sulphur compounds which cause odours occasionally, particularly during inversions.

The Phytotoxicology Section's 1985 survey of silver maple foliage found only trace amounts of visual injury due to air pollution, but only at three location close to the industrial complex.

The Air Resources Branch conducted a mobile van survey in the fall of 1985 and found levels of nitrogen oxides, carbon monoxide and the alkane fraction of total hydrocarbons increased around the City during inversions, and that this was due mostly to vehicle traffic. Increased concentrations of reduced sulphur compounds due to industrial emissions were also observed.

The van survey also monitored several "targeted" sources in the industrial area. Stelco and Dofasco were confirmed to be sources of total reduced sulphur, sulphur dioxide and nitrogen oxides and Domtar was confirmed to be a significant source of total reduced sulphur and hydrocarbon compounds, most of which were of the aromatic class, including naphthalene.

Low concentrations of all contaminants were measured near Columbian Chemicals and the sewage treatment plant on Woodward Avenue.

With the exception of reduced sulphur compounds, none of the applicable standards, criteria or guidelines were exceeded for any of the contaminants measured during the van survey.

Total reduced sulphur compounds are a major source of odours. Negotiations with industry for reductions of these emissions have been completed. Control programs are underway at Stelco, Domtar and Dofasco.

2. INTRODUCTION

The Air Management Program in Ontario is based on controlling man-made emissions to meet ambient air quality objectives, which in turn are based on known effects on health, quality of life or sensitive vegetation, whichever is most stringent. To achieve these objectives, sources of pollution are identified, their emissions evaluated and appropriate control measures are instituted. Ambient air monitoring is used to identify pollution sources and to verify that the controls have been successful. Monitors are mainly sited in areas suspected of experiencing higher levels of air pollution. When these areas achieve acceptable air quality, then it is assumed that other areas should also be acceptable.

3. MONITORING NETWORK

The Ministry of the Environment operates a network of ambient air monitors throughout Hamilton as shown in Figure 1 and Table 1. Monitoring is concentrated in the lower city, i.e., the area below the Niagara Escarpment, where for many years the network has been centered on two major stations which monitored a variety of pollutants with automated analyzers. The main station, known as 29025-Barton/Sanford provides the data which forms the basis for the Hamilton Air Pollution Index (API). The other major station is near Beach Blvd. and was known as 29008 - North Park, immediately adjacent to the Queen Elizabeth Way. In October 1984, the Skyway widening project necessitated the moving of the North Park station one kilometer south to the grounds of the former Bell Cairn School on Beach Blvd. The number of this new station is 29102.

In 1985, three new major air monitoring stations were established in the City in preparation for the new Air Quality Index. In January, an east end station 29105 was established at Nash Road and Kentley Drive. This was followed in July by a west end station 29118 on Main Street West at the Highway 403 cutoff, and finally in November by a mountain station 29114 on Vickers Road at East 18th Street. Data for this latter location is not included in this report since so little data was gathered.

The remainder of the network consists of numerous but less sophisticated monitors, and most of the network has been in existence since at least 1970. In addition to this regular network, special surveys are carried out on occasion in order to identify specific problems. Two special surveys were conducted by the Ministry's Air Resources Branch in 1985, the results of which are presented in this report. These surveys were the Phytotoxicology Section's annual survey of vegetation studies done

in the summer of 1985, and the Air Quality and Meteorology Section's three week survey with two mobile air monitoring vans in October 1985.

Meteorological data (wind speed, wind direction and air temperature) are observed at station 29026, at Woodward Avenue located on the sewage treatment plant grounds. In June 1984, lightning storms damaged the instruments on the tower, putting the station out of commission until November of that year. Later in March 1985, the old 200 foot tower was taken down and replaced in June with a new 300 foot tower. Consequently, data from Mount Hope Airport provided by Environment Canada, was used to fill in the missing periods for data analysis. Figure 2 presents the wind frequency distribution measured and clearly indicates the predominant west and southwest winds which occur in the area.

The results of a computer program known as a "pollution rose" are included in this report. The program is essentially a cross-tabulation of hourly pollutant concentrations (measured at the two main stations) with wind direction classes. The data from this program are illustrated on various diagrams in the report. For each "rose" presented, the length of each line drawn is proportional to the average concentration of a pollutant when the wind was blowing <u>from</u> that direction. The longest lines in the diagram usually point to a source or sources of the pollutant in question. The concentrations will be influenced both by the quantity of emissions and by meteorological conditions such as wind speed, etc. As a result, the program is a useful tool in source identification of pollutants.

4. ANALYSIS OF DATA

4.1 Air Pollution Index

The Hamilton air pollution index (API) is used as a warning system to alert the public to elevated air pollution levels and as a trigger for cutbacks in industrial emissions. It is derived from 24 hour average concentrations of sulphur dioxide and particulate matter as measured at the Barton/ Sanford station. The combination of these two pollutants at elevated levels has been shown to be at least indicative of detrimental human health effects. Hourly concentrations of both pollutants are telemetered to a central computer facility in Toronto which then calculates the index hourly, based on the following equation:

$$API = 2.5(13.9\ COH + 104.5\ SO_2^{.8})$$

Where: COH is the 24-hour average soiling index concentration expressed in coefficient of haze units.

SO_2 is the 24-hour average sulphur dioxide concentration expressed in parts per million.

No action is taken for readings up to 31. At 32, known as the advisory level, and with a forecast of unfavorable dispersion conditions, major point source emitters are notified and asked to voluntarily curtail certain operations. At an API of 50, cutbacks by these sources become mandatory. These levels are set with a considerable safety margin before health effects to sensitive people would be expected. At 75, further cutbacks would be ordered and at 100, all sources not essential to public health and safety could be ordered to cease operations.

The API station is located at the interface between the heavy industrial and residential areas of the city and about half-way between downtown and the integrated steel mills. It is directly downwind of the industrial area during times of poorest atmospheric dispersion. Hamilton's API levels are frequently compared to other areas in the Province. Such comparisons are not always valid since APIs in different cities are not strictly comparable. Hamilton's API station in particular, is more oriented to a large heavy industrial area than most of the other API stations in the Province.

During 1984, there were nine incidents in which the API reached or exceeded 32 as given in Table 2. The first incident on January 16 was unusual in that winds during the period were southwest. Levels throughout Southern Ontario were high due to a widespread subsidence inversion created by a stationary high pressure cell. The elevated pollutant levels were probably due mainly to long range emissions, as evidenced by the fact that much of the particulate measured was in the fine fraction and was composed largely of sulphate particles. One other incident on October 11-13 was also due to an inversion created by a high pressure cell, but winds then were more characteristically from the northeast.

The other seven incidents in 1984 were a result of the classical lake breeze phenomenon, in which a warm southerly air mass was undercut by a cool northeast breeze off a cold Lake Ontario.

In 1985, only two such incidents occurred, one in April and one in November. Both were due to the lake breeze inversion scenario.

A high variability in the numbers of incidents each year is shown in Table 2. This variability from year to year is weather related, that is, the frequency of typical inversion conditions.

It is important to note that the API station is located close to a major street - Barton Street, and at ground level and that the prime cause of the elevated API values is the soiling index (co-efficient of haze) term in the API equation. Peaks at rush hour, particularly during inversions are prominent in the data, as are reduced levels during night hours when traffic is reduced.

4.2 Particulates

There are three basic types of instruments employed for the measurement of particles, each type relating to a different size range:

(a) Dustfall jars measure heavy material, generally greater than 10 microns in diameter (one micron is one-millionth of a metre).
(b) High volume samplers measure suspended particulates ranging in size from submicron to 50 microns and
(c) Co-efficient of haze tape samplers measure mostly fine material - from submicron to about 10 microns.

The ambient air quality objectives for suspended particulate are based on health effects when occurring in combination with sulphur dioxide. As mentioned previously, this combination was proven to be indicative but not necessarily causative of such health effects. The dustfall objectives are based on nuisance effects while the soiling index objectives were derived from correlations with suspended particulate data.

4.2.1 Total Suspended Particulates

A high volume sampler draws a known volume of air through a pre-weighed filter for a 24 hour period (midnight to midnight). The exposed filter is weighed and the difference (weight of solids on filter) in conjunction with the known air flow is expressed as a concentration in micrograms per cubic meter. The objective for a 24-hour average is 120 ug/m^3 while the yearly geometric mean objective is 60 ug/m^3. At two locations in Hamilton, these devices operate daily. At eleven other locations, they run on a once every sixth day cycle, consistent with the practice in other North American jurisdictions.

Suspended particulate data is summarized in Table 3a and shows a definite gradient of higher concentrations closer to the industrial area. Concentrations in 1984 were generally higher compared to 1983 by an average of 9%. The increase may be due to the greater frequency of inversions plus a slight increase in industrial emissions due to increased production.

Some stations showed much larger increases such as 29001 downtown and 29090 in Westdale for reasons unknown; 29012 on Burlington Street which may have been affected by local construction activities due to a brewery expansion and 29008 North Park which may have been affected by harbour development and the Skyway widening project.

On April 30, 1984 a severe windstorm with southerly gusts of over 100 km/hr enshrouded the City in a dense yellow-brown haze. Microscopic analysis of the sampled dust showed that it was composed mostly of crustal material, probably emanating from freshly plowed fields south of the City. Most of the stations' 1984 maximums in Tables 3a and 3b occurred on this date.

In 1985, with the exception of two locations, dramatic improvements were noted through the City, as 10 stations averaged a decrease of 17% from 1984 levels. Largest improvements occurred downtown at 29001 and 29098, in Westdale at 29090, on the mountain at 29085 and in the west end at 29017. This latter station reduced to 61 ug/m^3, only slightly above the yearly objective following over a decade of averages in the 75-90 range. Fugitive dust sources in the area such as unpaved lots, road dust, stock piles, etc. were deemed responsible for the higher levels, but the improvement in 1985 is largely unaccounted for, except that as explained in the following discussion, a lessened "background" component entering the city may have been a factor in the overall improvement.

Another notable observation followed the move of station 29008-North Park to 29102-Beach Blvd. in 1985, which removed the old station from the direct influence of the Queen Elizabeth Way. Figure 3 displays pollution rose data in a histogram format, comparing averages for eight cardinal wind directions during 1981-84 at North Park and 1985 at Beach Blvd. It can be seen that lower averages were measured under northeast, east, south and southwest winds at the new station, all due to the lessened traffic influence. Averages were higher for north and northwest due to the Skyway bridge construction, and west because this direction places the station downwind of the heavy industries, whereas at North Park, west winds mostly "missed" the industries. Overall, the yearly mean decreased from 89 ug/m^3 at North Park in 1984 to 69 ug/m^3 at Beach Blvd. in 1985. Past studies have shown that the QEW contributed about 10 ug/m^3 to the annual mean at North Park relative to Beach Blvd. The further 10 ug/m^3 reduction could be related to the general improvement noted at the other stations.

Two stations in 1985 showed increases. One was 29011-Burlington/Leeds in the industrial area where unduly elevated levels occurred during the frequently occurring west wind sector. Construction activities in this direction were likely responsible. The other station, 29012-Burlington/ Wellington was also elevated similar to 1984, likely due to nearby construction activity.

The overall trend in TSP since 1970 is shown in Figure 4, which displays a leveling off in concentrations since 1977. The trend curve for industrial emissions shows a downward trend over this period. It is possible that the TSP curve does not follow because several stations were unduly influenced by localized emissions such as road traffic.

Pollution roses (Figure 5) for 1984-85 suspended particulates were manually calculated for the main stations (which sample daily) by grouping the data according to predominant daily wind directions (as opposed to the hourly pollution rose computer program which classes hourly data). Only those days for which a clear predominant direction could be determined were included and rainfall/snowfall days were excluded.

All three roses indicate a strong correlationship of high averages with winds from the industrial sector. Although a reduction in levels at 29102-Beach Blvd. was noted due to the lessening of the traffic influence, the industrial and remaining traffic contribution during west, southwest and south winds was still substantial in 1985, comparable to levels measured at Barton/ Sanford during northeast winds.

The hi-vol filters were analyzed for seven metals, as well as sulphates and nitrates (Table 3c).

Concentrations of nickel, cadmium, lead and vanadium showed very low concentrations which did not vary appreciably throughout the city indicating that these were background levels. The 24 hour criteria for these metals were easily met.

Concentrations of chromium and manganese showed a gradient with distance from the industrial area. However, the highest levels were well below acceptable levels.

Iron concentrations were high, and also showed a gradient with distance from the industrial area where concentrations were often well above general background levels, but usually below guideline values which are based mainly on soiling effects.

The sulphate/nitrate components comprised a large portion of the measured particulate matter. These constituents are largely by-products of major high temperature fuel combustion sources and can travel hundreds of miles from their source. The concentrations in Hamilton were generally higher in the industrial area, indicating a contribution from local industries. Elevated concentrations at most of the stations during northeast winds, confirms this. However, it should be remembered that northeast winds are often associated with inversion conditions. This results in poor dispersion, aggravating the build-ups of pollutants from all sources. Most of the City shows levels only moderately higher than other areas in the province including rural areas, indicating that much of this material is imported into the city via long range transport from distant sources. The sulphate/nitrate components are known to be a factor in reduced visibility[2] and are often likely responsible for the widespread haze observed in Hamilton during southerly winds.

Interestingly, the sulphate concentrations showed large reductions at most stations in 1985 similar to the suspended particulate results. The nitrate portion decreased only marginally if at all, in most cases. The reduction in sulphate levels which are largely imported into the city from distant sources, may indicate that the overall improvements observed in 1985 were largely due to this lesser "background" particulate entering the city.

It should be noted that the sulphate/nitrate analyses are subject to some error due to the measurement methodology and for this reason the data presented should be primarily used for evaluation of trends rather than use of the actual values. Alternative methodologies and filters are under investigation to improve the measurement technique. Concentrations of both parameters had been steady over the past several years prior to the reductions in 1985.

Beginning in 1985, four stations' hi-vol filters were analyzed for total carbon, elemental carbon and carbonate. Elemental carbon would include material such as coal, coke and kish, while total carbon would include numerous forms, both organic and inorganic in nature. Carbonate would include calcium carbonate (limestone) and dolomite. Sources of these carbonaceous materials would include coke ovens, blast furnaces, stockpiles, vehicle exhaust, biological materials and crushed stone.

Data is given in Table 3d and shows a distinct gradient in concentrations with distance from the industrial area. Levels were highest at 29011 in the middle of the industries, followed by 29025 and 29102 on the fringes of the area followed by much lower levels at 29085 on the mountain, confirming the industrial area's contribution to particulate levels in the immediate area of the mills. These higher

particulate levels are a result of both direct emissions and contributions from traffic, particularly heavy truck traffic.

McMaster University also continued hi-vol sampling as part of their study on the health effects of air pollution. Their sampling coincided with the Ministry sampling schedule, making their network of 12 hi-vols a useful supplement to ours. The samplers are mostly situated in residential areas on the mountain and remoter areas of the city and most recorded very low concentrations, generally within objectives (Table 3b). Most of the stations exhibited trends similar to the Ministry network. With the exception of one location, all McMaster hi-vols showed only one exceedence of the daily objective in both 1984 and 1985 and in both years, all of these exceedences occurred on single days, April 30, 1984 and May 31, 1985. Severe wind storms occurred on both days with southerly winds which blew up fugitive dust from both outside and inside the City.

The large dual network makes it possible to draw a contour map of suspended particulate concentrations, given in Figures 6 and 7. It can be seen that the majority of the city met the yearly objective of 60 ug/m^3. Concentrations were mainly only elevated close to the industrial area. The decrease in size of the 60 ug/m^3 contour in 1985 is very apparent. Once again it should be stressed that airborne particulate is not solely due to direct emissions from industrial sources, dirty roadways and heavy truck traffic can also be contributors.

It should be realized that these contour maps of concentrations are not a strictly definitive representation of city wide air quality. Local influences affect some of

the stations and several more stations are required to fill in some gaps that are not covered. More hi-vol sampling stations have been installed in 1986.

Although the contour maps in Figures 6 and 7 indicate a rather limited industrial contribution to suspended particulate levels throughout the city, it should be stressed that these maps reflect long term average conditions. Short term levels, particularly during inversions, accompanied by light northeast winds, indicate a different situation. Figures 8 to 12 depict suspended particulate contour maps during five elevated API incidents during the years 1983-85. Each map readily displays increased concentrations measured city-wide, diminishing with distance from the industrial complex. The contours are also skewed toward the southwest reflecting the northeast wind flow. The industrial contribution is obvious on these occasions whether it be direct emissions, fugitive emissions or roadway sources inside or outside plants in the industrial area. Under inversion conditions, with poor dispersion, pollution from all sources including traffic can accumulate and will contribute to the totals.

In conclusion, the suspended particulate data all tend to indicate that the industrial area does indeed have an impact on the City, but that the effect is usually limited to a relatively small area near the mill sites. During inversion conditions, broader impacts are noted.

Most major sources in industry have now been controlled and the remaining sources are being abated in compliance with Control Orders. These Orders include controls on cast houses for blast furnaces D and E and the No. 1 galvanizing line at Stelco and the No. 2 coke plant pushing emission controls at Dofasco. Dofasco is pursuing an agreed control program at

the No. 1 melt shop. Stelco is experimenting with efficiency improvements to the particulate scrubber at the sinter plant. Improved controls are being installed on the SWARU incinerator. Inside company properties, programs are in operation to control roadway sources of particulate. Roads have been paved and road cleaning is performed regularly. Better control of trackout to public streets still appears necessary, however. Improved road cleaning of public streets also appears necessary.

4.2.2 Soiling Index (Co-efficient of Haze)

Co-efficient of haze tape samplers operate continuously and determine hourly soiling values. Air is drawn through a filter paper, and the optical density of the soiled spot is measured by light transmittance. The instrument has readings taken prior to and after sample collection. The resultant light obstruction is determined and transmitted on a real time basis to the data bank for the two main telemetered stations while manual reading of charts is still required for three newly installed monitors. Data is given in Table 4.

In 1984, 29008-North Park showed a severe deterioration of about 30% from 1983. Construction activities related to the twinning of the Skyway Bridge were likely the major factor in the increase. However, in 1985 following the move of this station to 29102 on Beach Blvd., a dramatic decrease to well below the yearly objective occurred. Station 29008 had obviously been seriously impacted on by QEW traffic. The daily objective was exceeded only 3 times in 1985, compared to 79 times in 1984 at North Park.

Levels at Barton/Sanford remained slightly above the objective. A trend graph for both the Barton and Beach stations is given in Figure 13. The sharp drop in 1985 for

Beach is very apparent, while Barton has remained steady since the early 1980's. The change in the Beach average in 1985 leads to the conclusion that traffic emissions are the prime contributor to the soiling index measurement in the City. At Barton, the daily objective was exceeded 25 times in 1984, a year with frequent inversions and only 13 and 10 times in 1983 and 1985, years of infrequent inversions. On inversion days, soiling index peaks were very prominent at rush hours, as were reduced levels at night, when traffic was reduced.

As mentioned, new soiling index tape samplers were installed downtown at the Regional Health Office at Hughson and Hunter (29001), at new station 29105-Nash/Kentley and at 29118-Main Street West. These are the first of several newly built monitors which permit easily read chart readouts of the data. More will be installed in 1986. At 29001 downtown, levels were comparable to Barton/Sanford. Both 29105 and 29118 showed much lower levels well within the yearly objective (although 29118 only had four months of data in 1985).

Soiling index pollution roses given in Figure 14 indicate that while the industrial area was thought to be a large contributor to this measurement, such does not appear to be the case. While the downtown and Barton Street stations show the highest concentrations, and do show peaks under northeast winds up to about 0.8 COH's, these averages were inflated by inversion-time measurements which were largely traffic related. Both the east (29105) and west (29118) stations did not show peaks pointing at the industries. The east station is well located, being remote from traffic, while the west station is adjacent to the Highway 403 cutoff. The southeast peaks here point to this roadway. The Beach station does continue to show southwest peaks (from

industry), however, they are half of what they were at the old North Park station, and the new station still has the QEW and Beach Blvd. upwind during southwest winds.

It is important to note that while traffic appears to affect the soiling index measurement more than industry, industrial emissions may still be contributing. Another fine particulate monitor, also measuring particles less than 10 microns and known as a dichotomous sampler, is currently being used on an experimental basis. It correlates fairly well to suspended particulate results, while soiling index correlates poorly, probably explained by the fact that the dichotomous sampler and suspended particulate methodologies involve weight determinations, while the soiling index uses the light scattering properties of particles. Both the suspended particulate results and dichotomous results do show industrial contributions to particulate levels, especially during inversions. The soiling index measurement however, will be retained because it is the only practical method for measuring hourly concentrations.

4.2.3 Dustfall

Dustfall is that material which settles out of the atmosphere by gravity. It is collected in plastic containers during a 30 day exposure time. The collected material is weighed and expressed as a deposition rate of grams/square meter/30 days. The significance of observations is restricted to relatively local areas.

Dustfall levels in 1984 and 1985 (Table 5) remained similar to those of previous years. Figures 15 and 16 depict dustfall isopleths, and show that a small portion of the lower city and the Beach Strip near the industrial area was encompassed by the 9.0 grams/m^2/30 days contour which

represents twice our objective. Conditions in this area, for the most part were quite poor. Significantly, none of the 15 stations met the yearly objective in either year.

As with the suspended particulate contour maps, the dustfall contour maps are not strictly definitive representations of conditions city wide. Local influences affect some of the stations and the measurement is very imprecise. As well, some of the small contours drawn have no scientific validity. They are only drawn to indicate that particular stations are subject to local influences, unrepresentative of the general area.

Dustfall objectives are based on visible deposit of dust rather than health effects. Figure 4 shows that the levels throughout the city have remained virtually unchanged throughout the 1970's, a significant observation considering the considerable reductions in industrial process emissions and the correspondingly large reductions in suspended particulate concentrations noted in the same graph. Fugitive dust sources such as road dust, stock piles, unpaved areas, vehicle emissions, etc. are probably important in explaining this observation.

Road traffic is a major source of the dust at several of the stations. The North Park (29008) station recorded higher loadings on average than another location on Beach [illegible]. (29084) only two blocks away. Upon the move to 29102 in 1985, levels reduced substantially. As well, the locations on Concession Street at Upper Sherman (29031) and Mohawk Road at Camden (29030) recorded higher than expected loadings, probably due to the heavy traffic which passes directly by the stations. On Ottawa Street (29010), activities at the new hot strip mill at Dofasco have resulted in extremely high concentrations being observed, of which a large portion can

probably be ascribed to increased heavy truck traffic and quantity of dirt tracked onto the street near the station. The station at Chatham/Frid (29017) is also probably significantly affected by local fugitive sources such as road traffic and unpaved lots. Unlike suspended particulate concentrations, dustfall did not improve substantially in 1985 at this station.

Extensive control efforts such as the use of chemical sealants, road paving and road washing have taken place within company properties in the industrial area to control their fugitive dust emissions. However, no significant improvement in overall dustfall has occurred. In the future, the possibility of more extensive analysis of dustfall samples is being studied in order to better ascertain the sources of the material being sampled. Additional stations more remote from traffic may also be installed to study this effect. More landscaping and measures to reduce dirt trackout into streets may be necessary. Such undertakings are being performed on an ongoing basis by industry.

4.3 Sulphur Dioxide

Most sulphur dioxide (SO_2) emissions in Hamilton stem from industrial sources. A smaller portion is accounted for by fuel burning in domestic space heating. The Barton/Sanford and North Park/Beach Blvd. stations have monitored SO_2 for many years and in 1985, two new monitors were added in the east at 29105-Nash/Kentley and in the west at 29118-Main Street West. Data is summarized in Table 6, which lists objective values that are based on vegetation damage (hourly and yearly) and health effects in conjunction with suspended particulate (daily).

Sulphur dioxide trends from the Barton and Beach stations since 1970 are illustrated in Figure 17. In 1984-85, as in the past several years, the concentrations were acceptable based on the yearly objective and there were no readings above the hourly or daily objectives. The two new stations both showed even lower levels, indicating the smaller industrial influence.

The pollution roses for the stations are given in Figure 18 and confirm that the industrial area is the prime source of SO_2 in the city but that the effect is limited to the area near the industries. The east and west stations show little industrial influence. Local space heating likely affects these stations more.

4.4 Total Reduced Sulphur

This measurement is comprised of hydrogen sulphide (H_2S), the "rotten egg" gas and other sulphur compounds and the data is referred to as total reduced sulphur (TRS). There are no general objectives for TRS, however an hourly objective for H_2S of 20 ppb (based on its odour threshold) may be compared to the observed values since most emissions are thought to contain H_2S. Both Barton/Sanford and North Park/Beach Blvd. monitored this pollutant continuously and the data are summarized in Table 7.

The major sources of hydrogen sulphide and related sulphur compounds are the steel industry's coke ovens and related by-products operations, certain slag reclamation processes and under upset conditions, a local manufacturer of carbon black. The sewage treatment plant is another potential source of odours but only during certain upset conditions.

In 1984-85, there were 24 hours exceeding the H_2S objective at North Park/Beach Blvd. and 36 hours at Barton. As this exceedence statistic is more relevant than a yearly average, trends in the number of exceedences per year at the two stations are illustrated in Figure 19. Wide variation is evident from year to year in the graph, however, a trend to declining levels in the 1980's seems evident. Over the years, the Barton station generally tends to record more exceedence events than the Beach Blvd. station. This is probably because southwest winds are generally brisk and offer good dispersion for the Beach Blvd. area, while northeast winds are usually light and sometimes associated with inversions, offering poorer dispersion for the Barton Street station.

Not surprisingly, the TRS pollution roses for the stations given in Figure 20 point strongly toward the industrial area. The move of the Beach station to 29102 did not have a significant impact on the readings. Special monitoring surveys are currently underway to attempt to determine main sources of the elevated ambient concentrations in order to plan the most effective abatement strategies.

Programs are underway to reduce TRS emissions. Stelco is moving to replace the direct cooling towers on coke oven by-products plants. One was replaced in 1985 and the other is scheduled to be replaced in April, 1987. Both Stelco and Dofasco are modifying their slag quenching techniques to reduce TRS formation. Domtar is initiating a comprehensive control program which will be under the direction of a Control Order.

4.5 Carbon Monoxide

The major source of carbon monoxide is the automobile although there are also some contributions from industry. Due probably to automotive emission controls, the levels measured at Barton Street (Table 8) decreased greatly since the 1970's (Figure 21). In 1984-85, the levels were similar to the previous few years and were well below the objectives which are based on health effects.

A new carbon monoxide analyzer was installed in the North Park station in January 1984. Concentrations at North Park throughout 1984 and at Beach Blvd. in 1985 were lower than at Barton Street, explained by the fact that the high speed traffic on the QEW generates less carbon monoxide than the low speed traffic on Barton Street[3], and that the Beach Blvd. traffic load is much less than Barton Street - almost half[4].

The pollution roses given in Figure 22 indicate that southeast quadrant winds (from the intersection of Barton and Sanford Streets) followed by northeast quadrant winds (from industry) yield the highest averages at Barton, while North Park/Beach Blvd.'s highest averages (albeit very low) were from the southwest.

4.6 Oxides of Nitrogen

The primary source of oxides of nitrogen are high temperature combustion sources including the automobile. The most abundant oxides are nitric oxide (NO) and nitrogen dioxide (NO_2), and they were monitored continuously at Barton/

Sanford, North Park/Beach Blvd. and at the new west end site 29118 in the last half of 1985. At each station, a single instrument makes measurements of NO, NO_2 and total nitrogen oxides. Nitric oxide is measured directly, and the total oxides are measured by internally converting all other nitrogen oxides to nitric oxide. The instrument then determines nitrogen dioxide to be the difference between the first two measurements.

Objectives exist only for nitrogen dioxide and these are based on odour threshold levels (hourly) and health effects (24-hourly). Other adverse effects occurring at much higher levels include vegetation damage, reduced visibility and corrosion of metals. The objectives were not exceeded in 1984 or 1985 similar to previous years.

Data for nitrogen dioxide are given in Table 9 and yearly trends since 1975 are illustrated in Figure 23. Both Barton and Beach stations showed similar concentrations to previous years but slightly higher than at the new west end site 29118 on Main Street West, indicating a small contribution from industry. A levelling off in concentrations at the two established stations is evident in the trend graph.

Data for nitric oxide are given in Table 10 and yearly trends for Beach and Barton are given in Figure 24. Note the huge decrease in levels at Beach following the move to 29102 in 1985. The station is now obviously less impacted on by vehicle emissions. The new Main Street West site recorded higher levels in 1985 than the other two; it obviously is being affected by traffic on Main Street West and the Highway 403 cutoff.

Pollution roses for the two measurements are given in Figures 25 and 26. The roses for NO_2 both seem to indicate an equal contribution from industry and traffic, however, the NO levels at all stations were clearly due mostly to traffic. The very high 29008-North Park NO levels for 1984, evident in Figure 26, can be accounted for by several factors. Firstly, vehicle emissions of oxides of nitrogen consist primarily of NO (which is later oxidised to NO_2 in the atmosphere) and the high speed traffic on the adjacent QEW generated more NO than low speed traffic on Barton Street and Beach Blvd. Secondly, more diesel truck traffic which also generated more NO, passed by North Park than at the Barton Street and Beach Blvd. stations[3]. The new west end site also shows a very high average concentration from the southeast quadrant, pointing at the Highway 403 cutoff. This section probably has a very high traffic count.

Oxides of nitrogen are an important factor in the photochemical production of ozone which will be discussed in the next section of this report.

4.7 Ozone

Oxidants are produced by photochemical reactions involving oxides of nitrogen, hydrocarbons and sunlight. Ozone accounts for most of the oxidants produced. The sources of the precursor pollutants are mainly industrial and automotive.

Ozone is known to be associated with many respiratory problems, and at very elevated concentrations, people can experience adverse health effects. Ozone is also injurious

to different types of vegetation including certain tobacco and tomato crops. The one-hour objective for ozone (.08 ppm) is based on such vegetation effects.

Ozone concentrations follow very definite annual and daily trends. Highest levels occur during the summer (May - September), and the daily maxima usually occur during mid-afternoon. Both patterns are directly related to temperature and the amount and intensity of sunlight.

Ozone was measured at the Barton Street station, and in 1985 at the new east site 29105-Nash/Kentley and west site 29118-Main Street West. Data is summarized in Table 11 while yearly trends at Barton are illustrated in Figure 27.

In 1984-85, concentrations on average were generally similar to previous years at Barton, recording only 24 hours above the hourly objective during the two summer periods. The other two stations recorded similar levels to Barton in 1985. The higher concentrations when they occurred, were widespread, occurring concurrently throughout the City and Southern Ontario during periods of southerly or southwesterly winds. Their origin is believed to be in the United States. The pollution rose in Figure 28 computed for the May - September period confirms that highest concentrations occurred under winds from the southwest quadrant. The peaks from these directions are not overly prominent because southwest winds do not automatically yield high ozone levels. Specific meteorological conditions are necessary.

Ozone, hydrocarbons and oxides of nitrogen can be transported over great distances and can be augmented by local sources. However, Hamilton and other major urban areas usually experience lower ozone concentrations than their more rural surroundings during peak occurrences. In fact, the

concentrations in Hamilton are among the lowest recorded in Southern Ontario, probably due to the numerous high temperature combustion sources which produce scavengers of ozone such as nitric oxide. Nonetheless, ozone and other oxidants remain a problem which, due to the complexity of their formation and the long range transport phenomenon, will have to be resolved on a national and international rather than local scale.

4.8 Fluoridation

This measurement is a relatively crude assessment used to determine quantities of various fluoride compounds in the ambient air. A lime coated paper is exposed to the atmosphere for one month and is then chemically analyzed for fluoride. The fluoride objectives are based on vegetation damage and for this reason, the objective is more stringent during the growing season. For the period of April 15 to October 15, it is 40 micrograms/100 square centimeters/30 days while for the remainder of the year it is 80.

In Hamilton, the major fluoride sources are the basic oxygen furnaces used by the major steel industries which require fluorspar as a fluxing agent. In addition to these process emissions, there are other minor sources such as coal burning, since coal contains trace amounts of fluoride. A brick manufacturing plant at the base of the escarpment near Gage Park is the only non-steel industry source.

Data for 1984-85 is summarized in Table 12 and the yearly trend since 1970 is illustrated in Figure 29.

The trend graph shows that levels have declined gradually since 1982 following large reductions in concentrations which began in 1971.

Further improvements occurred in 1984-85, declining by about 30% from 1983 levels. Highest concentrations continued to be observed in the industrial area at station 29059-Burlington/Gage and at the Beach Blvd. area at 29058-QEW/Skyway. Levels were significantly lower than in previous years at these locations despite slightly higher industrial production levels. About half of these samples exceeded objectives. The higher levels of fluoride at 29058 appear to be related to traffic on the adjacent QEW. The higher levels at station 29059-Burlington/Gage are likely due to its proximity to the major sources.

The remaining stations more remote from industry, showed lower concentrations with only occasional and marginal exceedences of the objectives. The 1985 Phytotoxicology Assessment Survey, given in the Appendix, indicated that injury to silver maple foliage due to fluoride was restricted to three stations close to the industrial zone. The injury, however, was only in trace amounts.

5. MOBILE MONITORING SURVEY - 1985

Between October 15th and November 6th, 1985, an intensive ambient air quality survey was undertaken by the Ministry's Air Resources Branch throughout the city by two mobile air monitoring units. Air quality profiles were established under adverse weather conditions and in the vicinity of several "targeted" sources in the industrial complex along Burlington Street. In particular, the adverse weather condition was that of daytime and nocturnal inversions and the "targeted" sources were Domtar, Stelco, Dofasco, Columbian Chemicals, and the sewage treatment plant on Woodward Avenue. In addition, four over-night monitoring sites were utilized in order to determine general air quality profiles throughout Hamilton. These were the Harvester site at the north end of Sherman Avenue, Pier 24/25 at the north end of Strathearne Avenue, a Public Works Department yard in the Chedoke area and Mohawk College on Fennell Avenue.

Some 70 different monitoring periods comprised of approximately 872 hours of common contaminant data (i.e. for CO, TRS, SO_2, NO_x, O_3 and RHC) and 99 gas chromatographic samples for specific hydrocarbons analyses were acquired.

From all of the common contaminant data acquired downwind of the "targeted" sources, some elevated concentrations of CO, TRS, SO_2, RHC and NO_x were measured. In particular, Dofasco was a source of TRS and NO_x (the respective maximum 30-minute average concentrations being 0.027 and 0.24 ppm), Stelco a source of TRS, SO_2, and NO_x (the respective maximum one-hour average concentrations being 0.087, 0.15 and 0.22 ppm), Domtar a source of TRS and non-methane hydrocarbons (the respective maximum 30-minute averages being .100 ppm and 1.00 ppm), whereas for the other sources, i.e. Columbian Chemical and the sewage treatment

plant, low concentrations were measured. The steel plants and vehicular traffic also contributed significantly to the downwind concentrations of CO - the normal concentration level for this contaminant was usually in the range of several ppm.

From the sampling locations removed from Domtar, usually 40 to 60 specific organic compounds were identified and quantified with the averaged total hydrocarbon loadings ranging up to 500 ug/m^3. These loadings were usually dominated by a uniform alkane fractional component (up to approximately 200 ug/m^3) that could be attributed to the use of fossil fuels - especially vehicular exhaust. The aromatic fraction accounted for the most variability in these loadings (average loadings ranging between 40 and 300 ug/m^3) and the most dominant sub-group of this fraction was the BTX's (benzene, toluenes and xylenes) with individual loadings usually less than 50 ug/m^3. Very little chlorinated organics were detected in any of these samples - usually less than 10 ug/m^3 in total.

From the Domtar sampling, the total hydrocarbon loadings ranged from 127 to 1650 ug/m^3 with a mean concentration of 700 ug/m^3. The alkane fraction accounted for 23% of these loadings (mean concentration of 161 ug/m^3), the aromatic fraction 69% (mean concentration of 484 ug/m^3) and the chlorinated fraction 5% (mean concentration of 32 ug/m^3). Napthalene was identified as well but although its concentrations appeared to be significant, it could not be quantified.

The emissions from the Burlington Street industrial complex were detected at all sites during this survey. None of the applicable environmental standards, criteria or guidelines were exceeded at any time for any of the measured

contaminants detected. However, the guideline for total reduced sulphur compounds which was developed to control emissions from kraft pulp milling operations was approached and exceeded downwind of Domtar and Stelco.

During inversion conditions on October 17, 22 and 29, sampling was conducted city-wide and at the over-night sites. The Air Pollution Index peaked at 18, 25 and 16 respectively during these incidents. From the common contaminant data, marginally elevated levels of CO and NO_x were measured (maximum one-hour averages being 3.3 ppm and .21 ppm respectively). Highest levels were detected in the industrial area. Elevated levels of SO_2 and TRS were also detected close to the steel works (maximum one-hour averages being .08 ppm and .024 ppm respectively).

From the analyses of the gas chromatographic samples, the average of the total hydrocarbon loadings was only 221 ug/m^3 and on the average, 42 specific hydrocarbons (out of a possible 126 compounds) were identified in these samples. The alkane fraction comprised 62% (a mean loading of 136 ug/m^3) of the total hydrocarbon loadings, the alkene fraction 6% (a mean loading of 13 ug/m^3), the aromatic fraction 24% (a mean loading of 52 ug/m^3) and the chlorinated organic fraction 5% (a mean loading of 10 ug/m^3). By far, the most dominant class of organics was the alkanes and within this class, the loadings of the dominant specific hydrocarbons (i.e. propane, butane, 2-methylbutane, pentane, 2-methylpentane and hexane) ranged, on the average, between 7 and 27 ug/m^3. Similarly the average loadings of the BTX's (benzene, toluene and xylenes), the dominant sub-group of the aromatics, ranged between 10 and 17 ug/m^3.

In summary, for measurements acquired under daytime inversion conditions, an increase in the concentrations of NO_x and CO was noted along with a relative increase in the alkane loadings as compared to the other fractional groups determined from the GC analysis. Vehicular traffic emissions are deemed to be the most probable major source of these contaminants. Elevated TRS levels above odour thresholds were also detected at various locations. These would be industrial source related.

No environmental standards, criteria or guidelines were exceeded for any of these monitored contaminants during these monitoring periods.

6. DISCUSSION

The main air pollution problem in Hamilton, apart from occasional odours and heavy dust fallout in the industrial area, is short-term pollution build-ups during the spring and fall due to the presence of temperature inversions. The sources of the pollution are both vehicle traffic and industry.

During 1984, industrial production in Hamilton was slightly higher and combined with a greater frequency of inversion conditions, particulate levels increased moderately at most monitoring stations. Also due to the greater frequency of inversions, the Air Pollution Index (API) reached the advisory level of 32 on nine occasions, compared to only once in 1983. In 1985, suspended particulate levels reduced substantially as did the frequency of inversion conditions. Industrial emissions were also slightly reduced. The API reached the advisory level of 32 only twice. Since emissions of pollutants during each year were fairly similar, the significance of weather variability becomes evident. The city's unique topography makes it very susceptible to inversions during which times pollution build-ups are unavoidable, and therefore, such incidents are likely to recur in the future.

Significantly, soiling index measurements, a measure of fine particles less than 10 microns in size and hence, a more health related parameter, were shown to be primarily related to traffic sources rather than industry and become particularly acute during inversion conditions, especially adjacent to roadways. Industrial emissions do contribute as well but probably to a lesser degree. Importantly, this conclusion relates to the soiling index measurement. Another new sampling methodology, which also measures fine particles less than 10 microns and which is still under development, yields results comparable to suspended particulate data.

The 1985 Phytotoxicology Section's annual chemical analysis of silver maple foliage indicated that fluoride, boron and iron values were elevated in proximity to the industrial area and decreased with distance, confirming the industries as a source(s) of these elements. Fluoride and iron exceeded background values in 1985 at only one station located closest to the steel mills. In general, the fluoride and boron (at most sites) values continued to decline in 1985 but, at the same time, iron concentrations were higher than in recent years. Lead, sulphur, zinc, sodium and chloride values were all well within their respective normal concentration ranges, although the concentrations of these elements were frequently higher near the steel mill complex. Concentrations of most of the measured parameters have generally decreased since the phytotoxicology surveys began in Hamilton in 1973.

The Air Resources Branch mobile van survey in 1985 showed that during inversion conditions, increased concentrations of nitrogen oxides, carbon monoxide and the alkane fraction of total hydrocarbons were noted throughout the city and that these increases were due mainly to vehicular exhaust. No standards or guidelines were exceeded. Total reduced sulphur measurements showed levels mostly below relevant objectives. However, odour thresholds were exceeded in parts of the city indicating the industrial contribution during these conditions. Close to the industrial area, high short term levels, well above objectives and odour thresholds were noted.

The van survey also confirmed Stelco and Dofasco to be sources of total reduced sulphur, sulphur dioxide and nitrogen oxides. The Domtar plant was found to be a source of total reduced sulphur and hydrocarbon compounds, most of which were of the aromatic class, including napthalene. With the exception of TRS, no relevant criteria, standards or guidelines were exceeded. Low concentrations of all contaminants were measured near Columbian Chemicals and the sewage treatment plant on Woodward Avenue.

Data from the previous few years showed small rises and decreases in industrial emissions with corresponding rises and falls in measured suspended particulate levels. This indicates that overall air quality improvements through further industrial abatement might still be achieved to some degree. However, the remaining pollution sources are difficult to control. Work is continuing in order to reduce these emissions through existing Control Orders. There is also a significant influence of long range transport of particulates from outside the city, mainly the U.S., and this effect is visible throughout Southern Ontario.

Dustfall levels throughout the city have not improved at all since 1970 despite huge decreases in industrial process emissions and control efforts by the larger industries within their properties to control fugitive dust, such as the use of chemical sealants, road paving and road washing. This indicates that other pollution sources on which no emphasis has yet been placed will also require control wherever possible. These sources can be both industrial and non-industrial in nature, such as blowoff from unpaved areas, excavation, construction, demolition, road traffic and stock piles. Existing efforts by the industries may also have to be increased.

As mentioned in an earlier section, the Hamilton air monitoring network has been expanded to include three new major stations:

- in the east end at Nash/Kentley,
- in the west end on Main Street West/Highway 403,
- on the mountain on Vickers Road near Upper Wentworth.

This expansion is in response to the installation of a new provincial data telemetry system which will allow for all new stations and many existing stations to be telemetered directly to a central computer facility in Toronto, allowing for data

retrieval on a real-time basis. Currently, only a fraction of West Central Region continuous monitors are telemetered to Toronto. The remainder of the Region's stations require manual reading of strip charts which causes delays of several months in data availability. The new system will allow for immediate access to data, both in Toronto and in the Hamilton office and will permit remote control and maintenance of instruments, all resulting in a more efficient monitoring program.

Once the new system has been installed, probably in 1987, a new Air Quality Index (AQI) will be added to the current Air Pollution Index which refers to only two pollutants. The AQI will be a function of six different pollutants, which will form up to eight separate subindices. Concentrations of sulphur dioxide, soiling index, carbon monoxide, nitrogen dioxide, total reduced sulphur and ozone will all be individually converted to the current scale of index numbers with the same advisory or alert levels of 32, 50, 75 and 100. The current API will be retained as one sub-index and will continue to be used for industrial action requests should the API reach 32 or higher. Not all AQI stations will measure all six pollutants and all eight subindices but the highest sub-index measured and the pollutant causing it will be reported to the public. In Hamilton, four separate AQIs will be reported for the three new stations and the existing API station at Barton/Sanford. The need for more than one index station in Hamilton has been apparent for some time as air quality can vary widely throughout the city at any given time.

The intent of the new index is to better inform the community about day to day air quality.

7. Acknowledgment

Thanks to Mr. Stephen A. Toplack of the Urban Air Environment Group at McMaster University for providing their suspended particulate data.

Thanks also to the Atmospheric Environment Service of Environment Canada for providing the Mount Hope Airport wind data.

8. References

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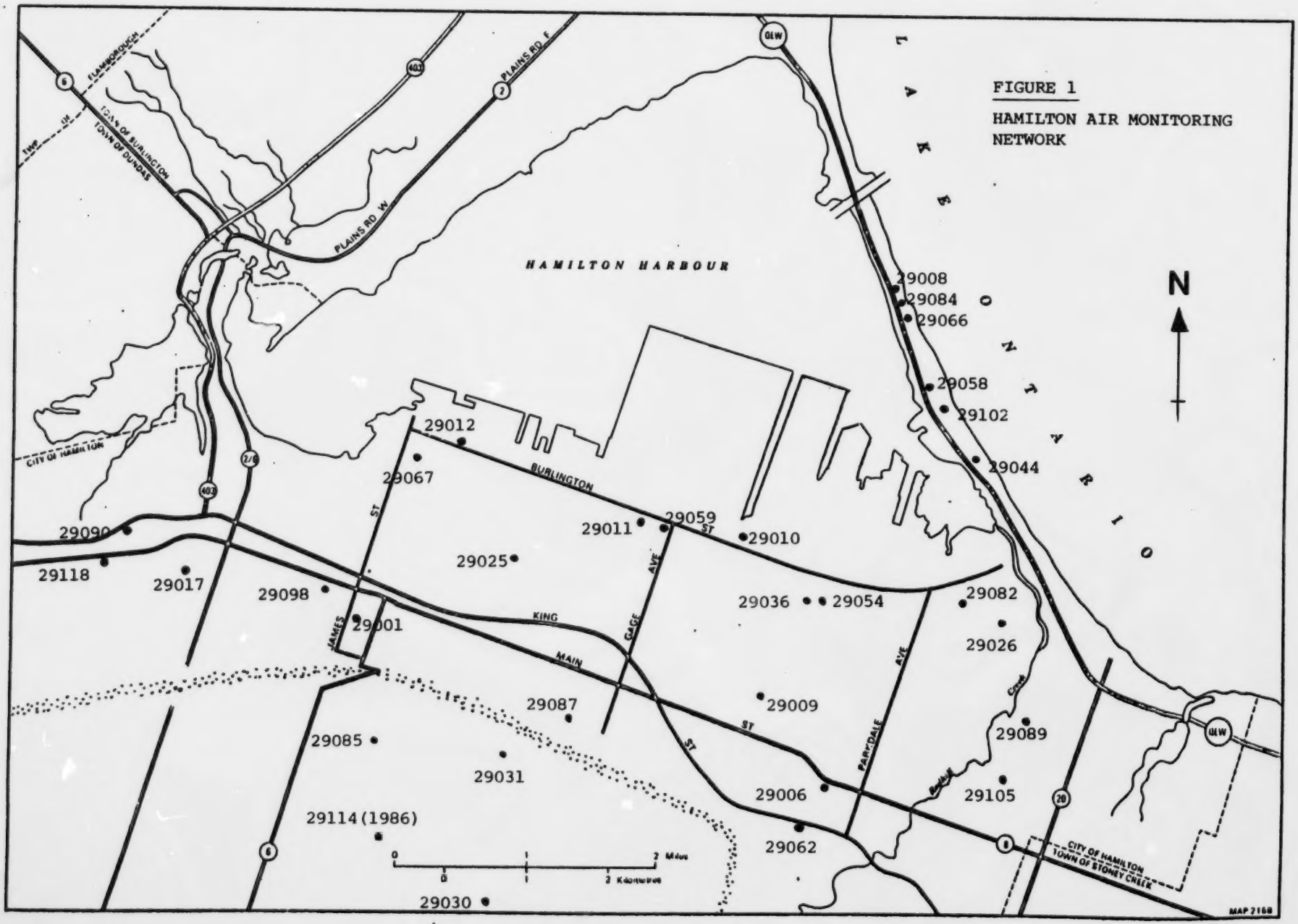


FIGURE 1

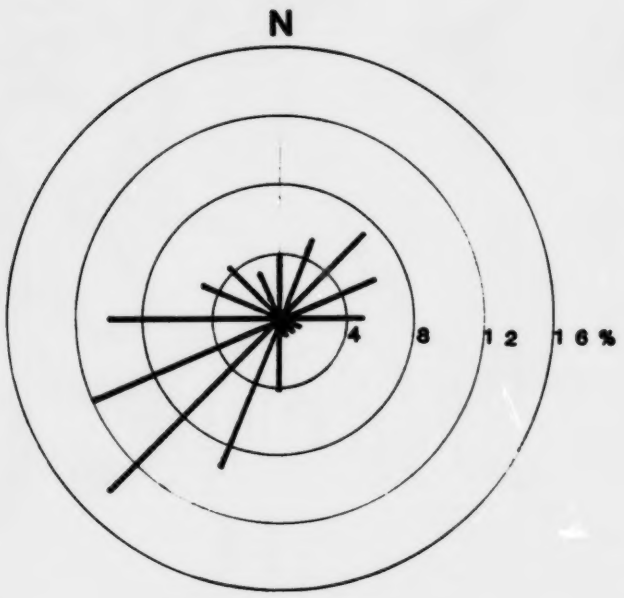
HAMILTON AIR MONITORING NETWORK

FIGURE 2

WIND FREQUENCY DISTRIBUTION

HAMILTON 1984-85

29026 - Woodward Ave & Mt. Hope Combined*



* Mt. Hope Airport data included for periods June 19-November 15, 1984 and Mar. 22 - June 21, 1985

FIGURE 3

TSP POLLUTION ROSES

29008 NORTH PARK VS 29102 BEACH BLVD.

HAMILTON 1981-1985

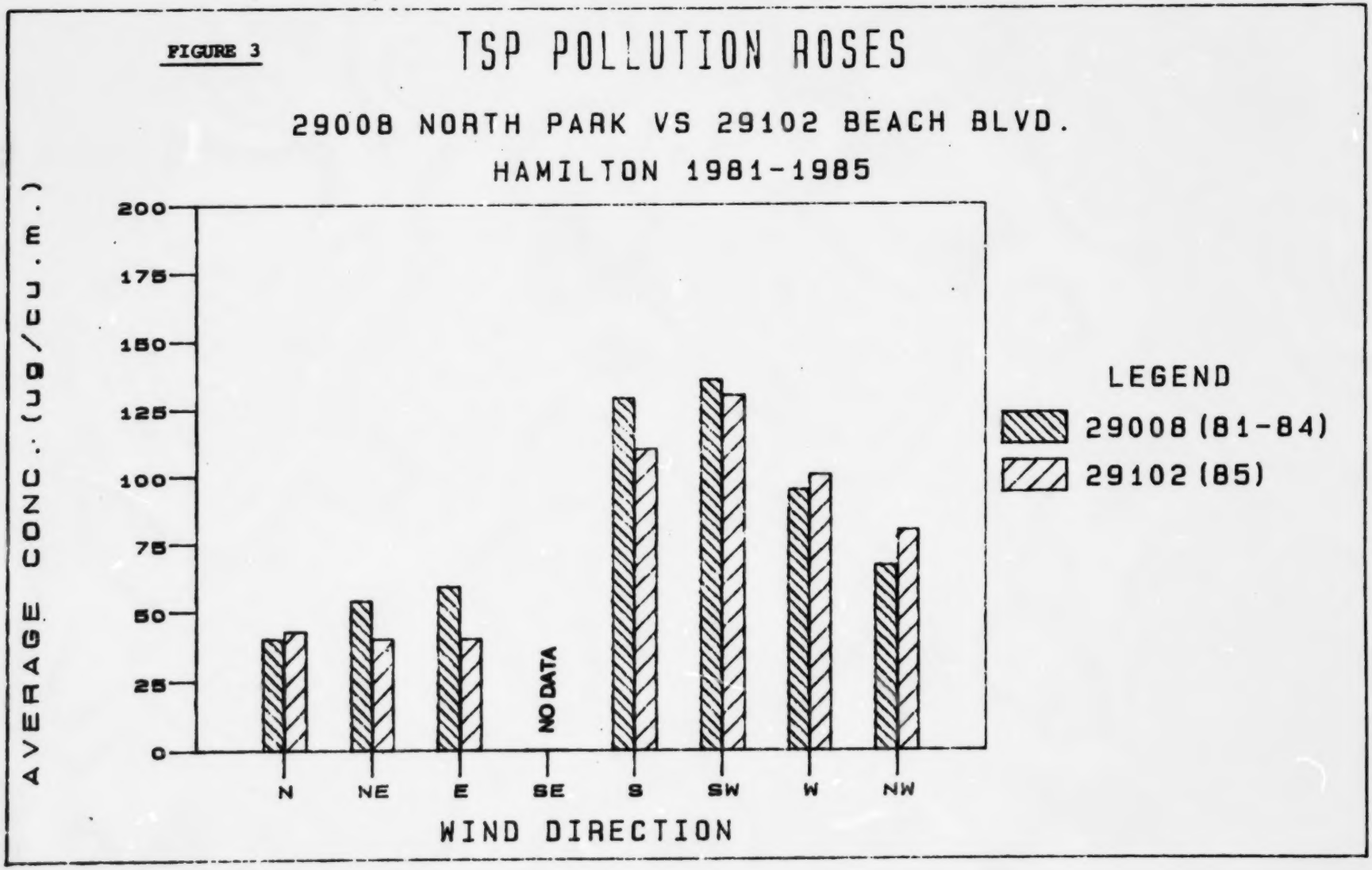
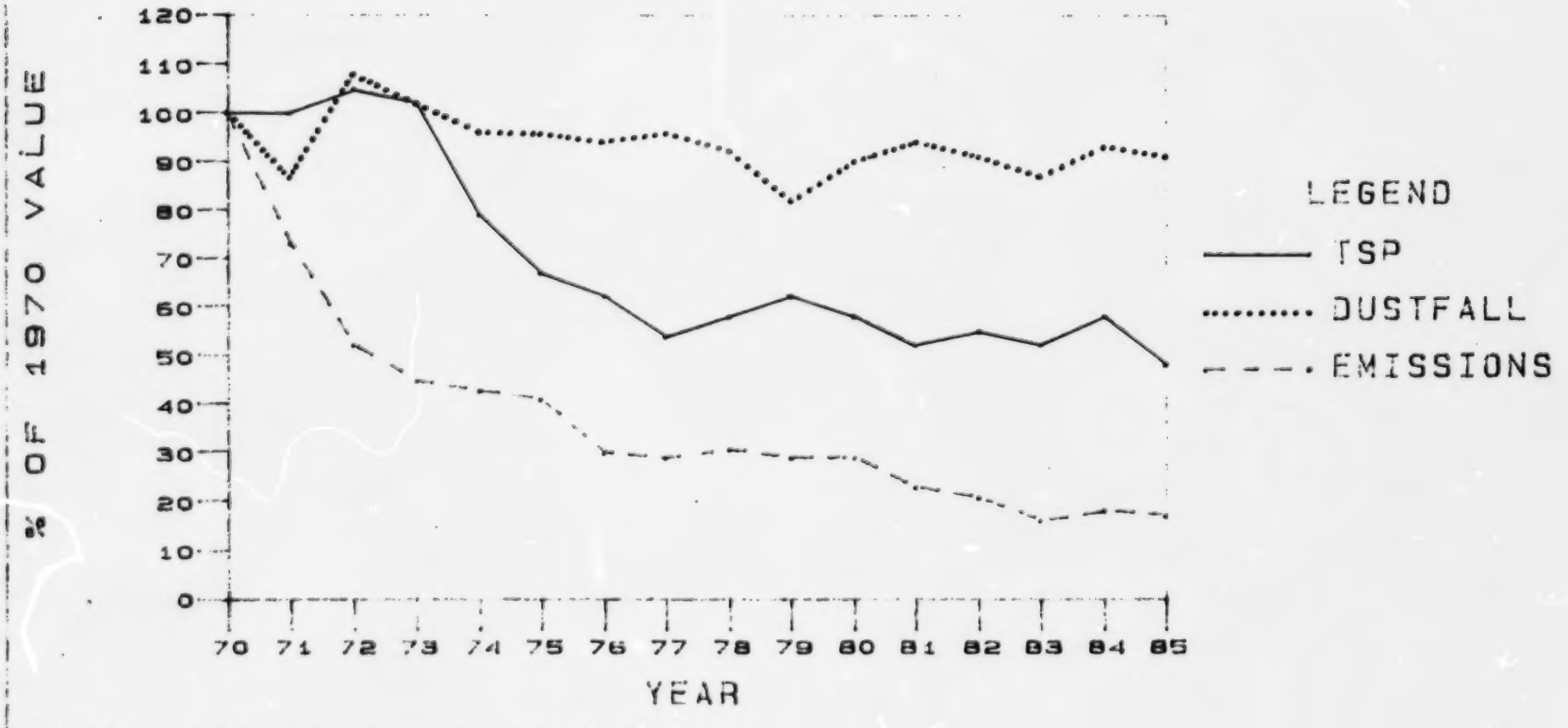


FIGURE 4

PARTICULATE TREND VS ESTIMATED EMISSIONS

HAMILTON



DUSTFALL -12 STATION AVG./TSP-6 STATION AVG.

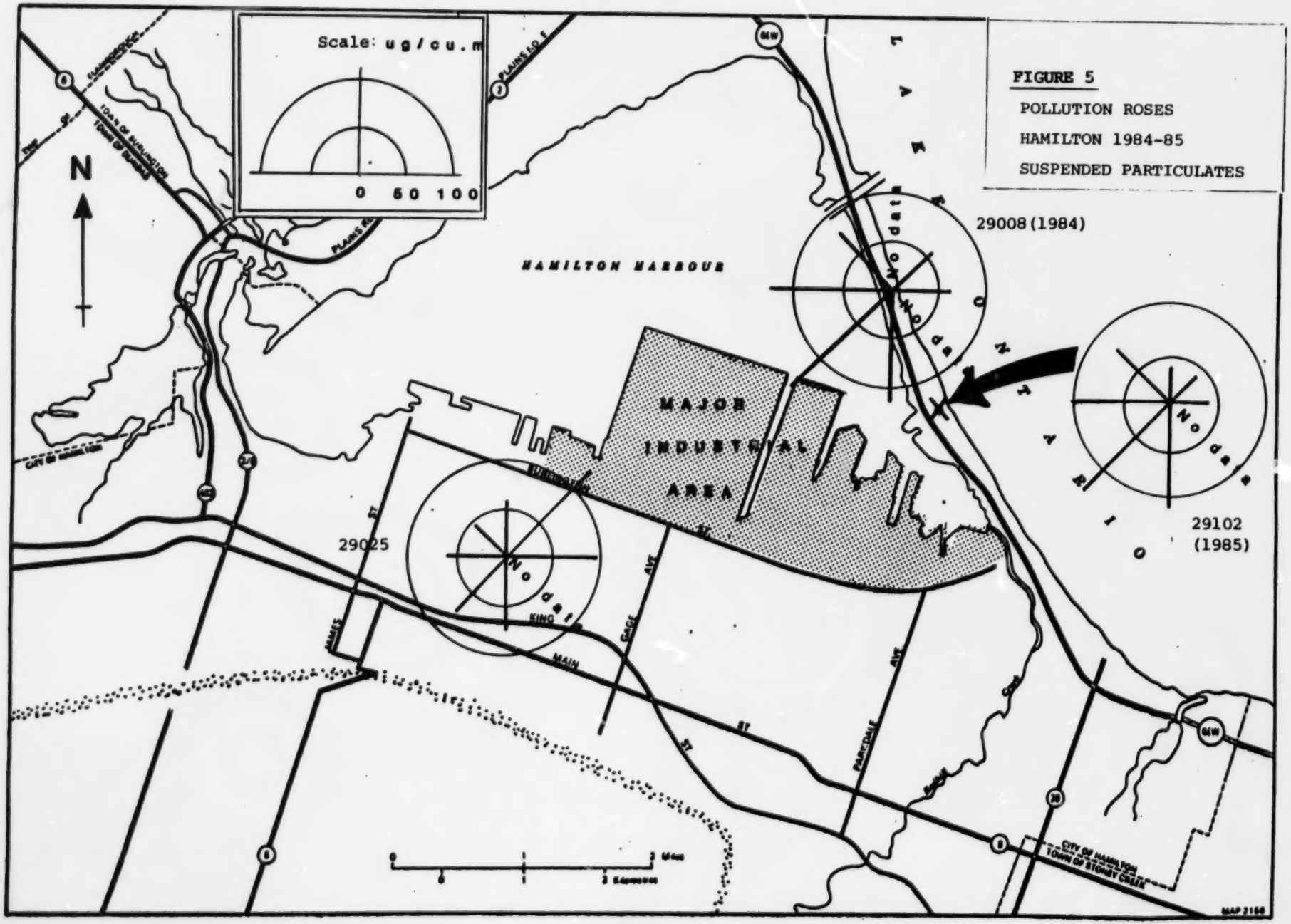
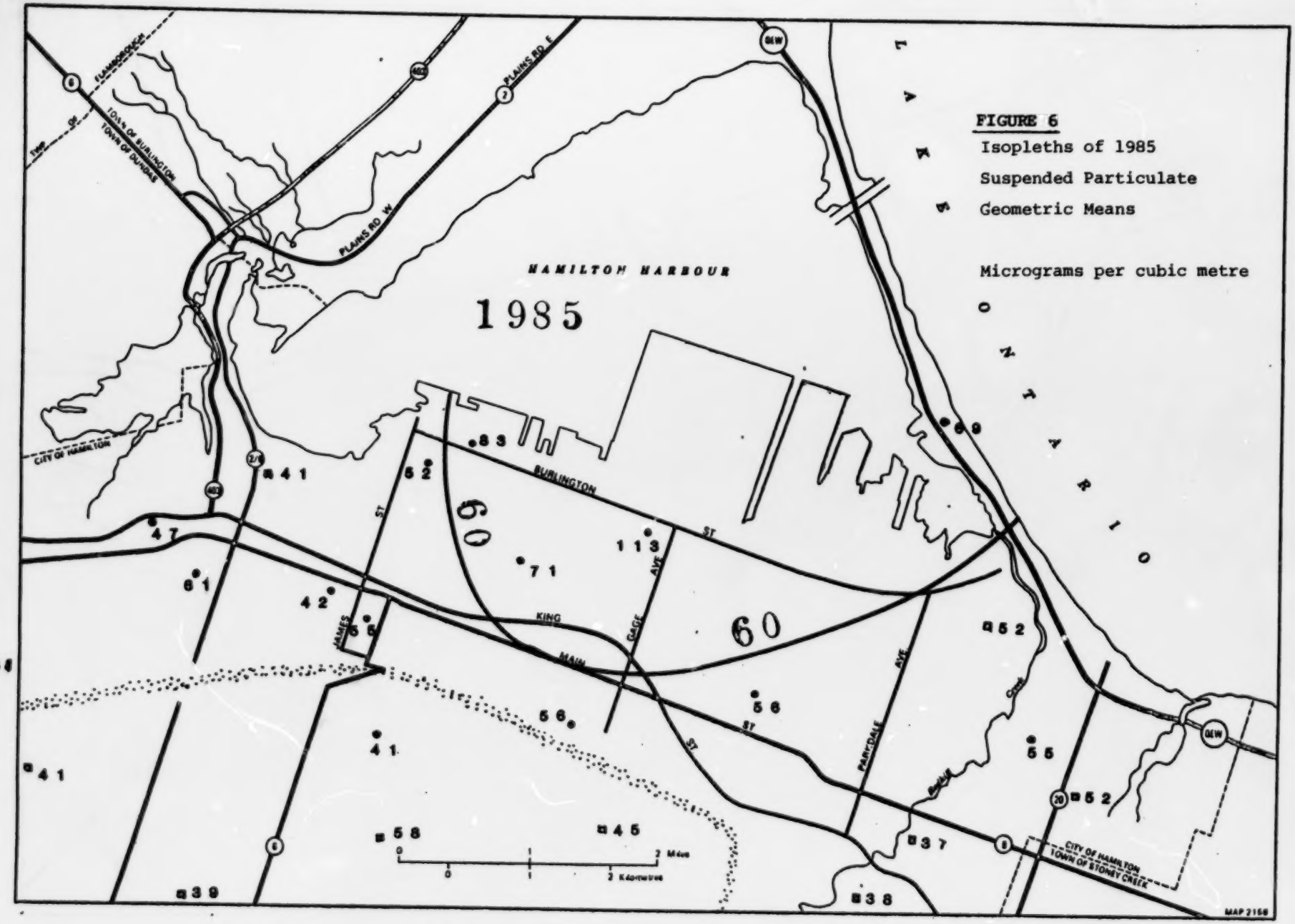


FIGURE 5

POLLUTION ROSES

HAMILTON 1984-85

SUSPENDED PARTICULATES


HAMILTON HARBOUR
1985
LAKE ONTARIO
FIGURE 6
Isopleths of 1985
Suspended Particulate
Geometric Means
Micrograms per cubic metre
60
60
BURLINGTON ST
KING ST
MAIN ST
JAMES ST
GAGE AVE
PARKDALE AVE
PLAINS RD W
PLAINS RD E
TWP OF BURLINGTON
TOWN OF DUNDAS
CITY OF HAMILTON
CITY OF HAMILTON
TOWN OF STONEY CREEK
QEW
MAP 2156

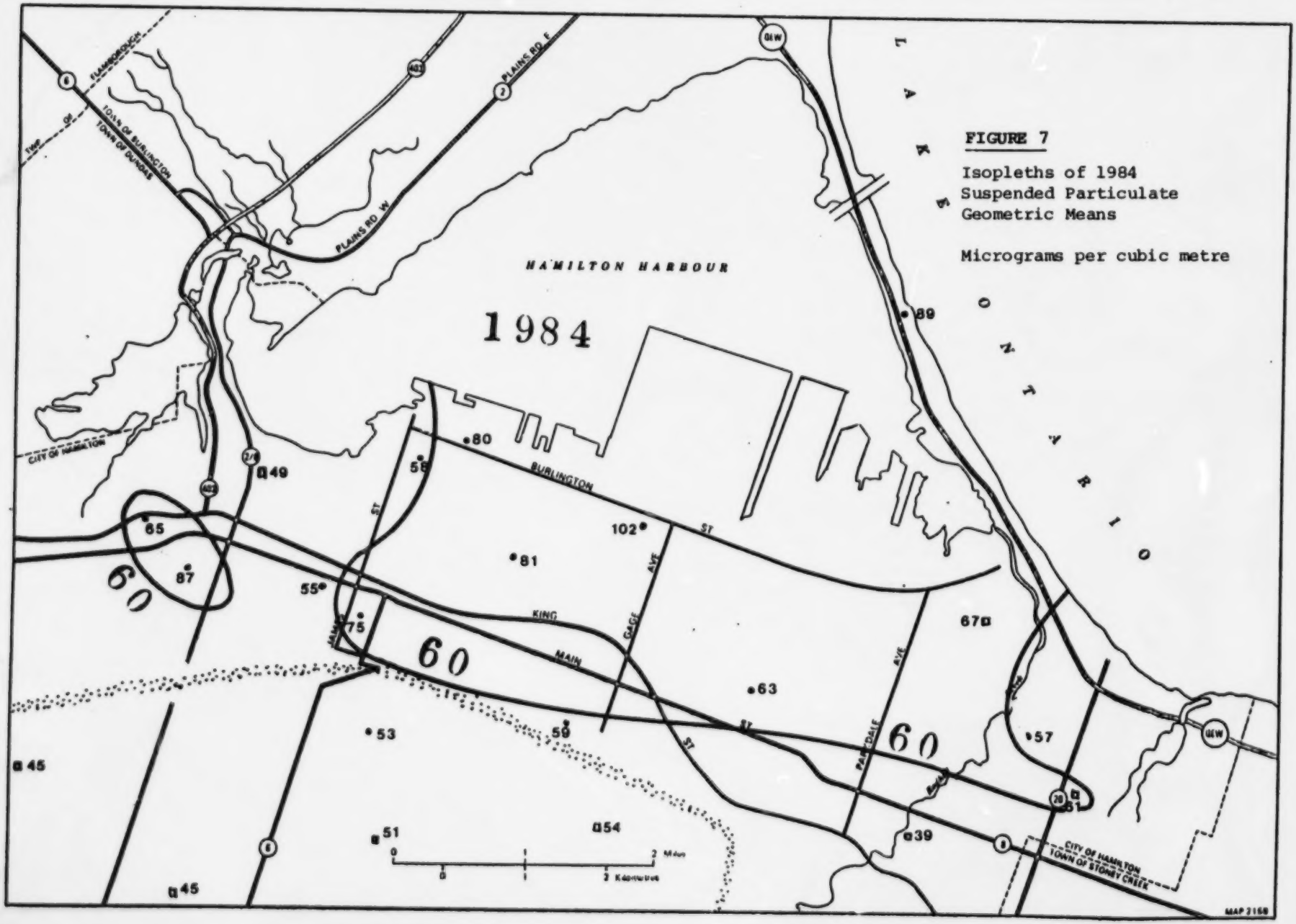


FIGURE 7

Isopleths of 1984
Suspended Particulate
Geometric Means

Micrograms per cubic metre

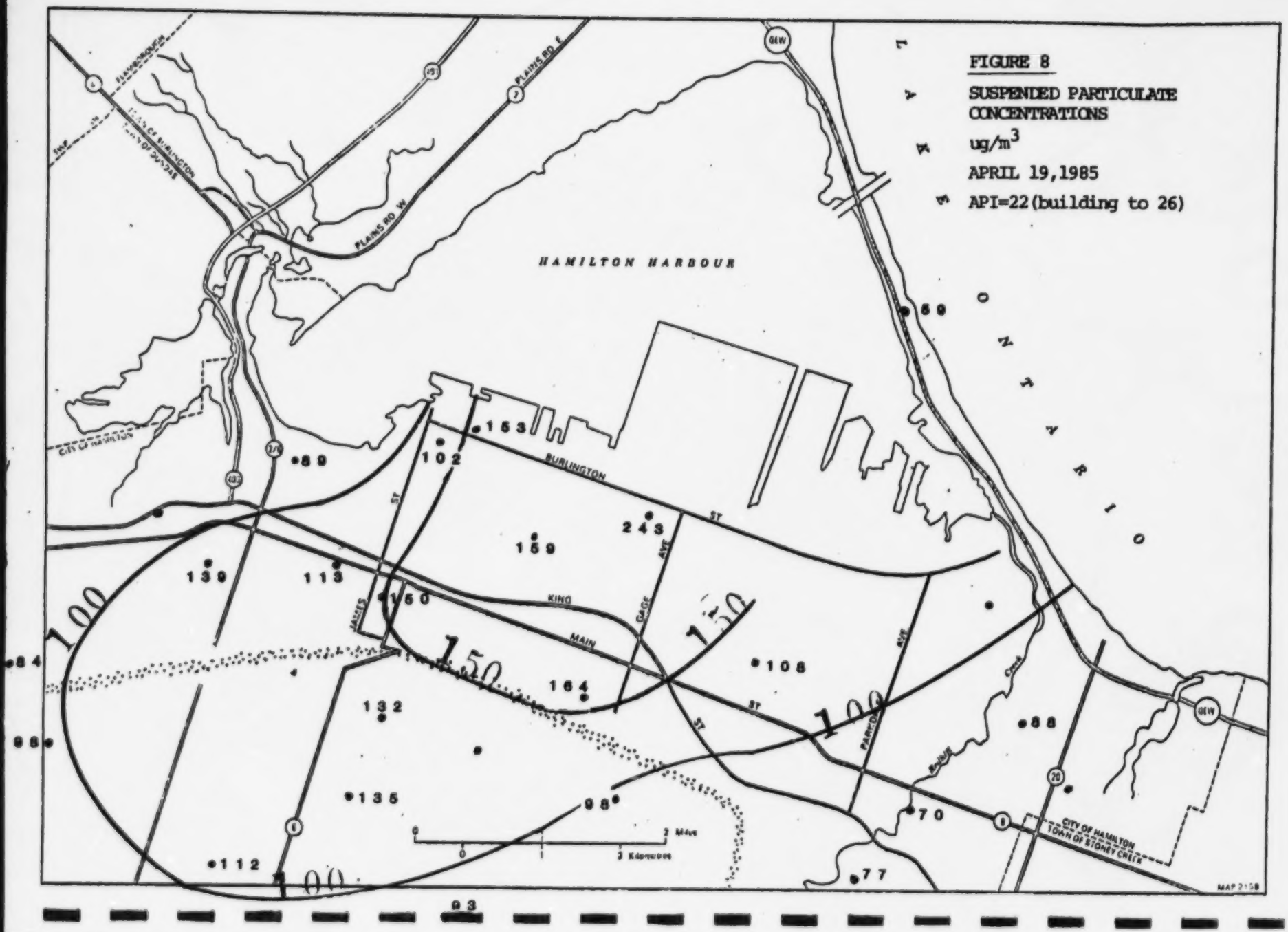


FIGURE 8
SUSPENDED PARTICULATE CONCENTRATIONS
ug/m3
APRIL 19,1985
API=22(building to 26)
HAMILTON HARBOUR
LAKE ONTARIO
BURLINGTON ST
KING ST
MAIN ST
JAMES
GAGE AVE
PARKDALE AVE
PLAINS RD W
PLAINS RD E
QEW
CITY OF HAMILTON
TOWN OF STONEY CREEK
153
102
89
159
243
139
113
150
108
164
132
84
98
135
88
112
70
77
93
100
150

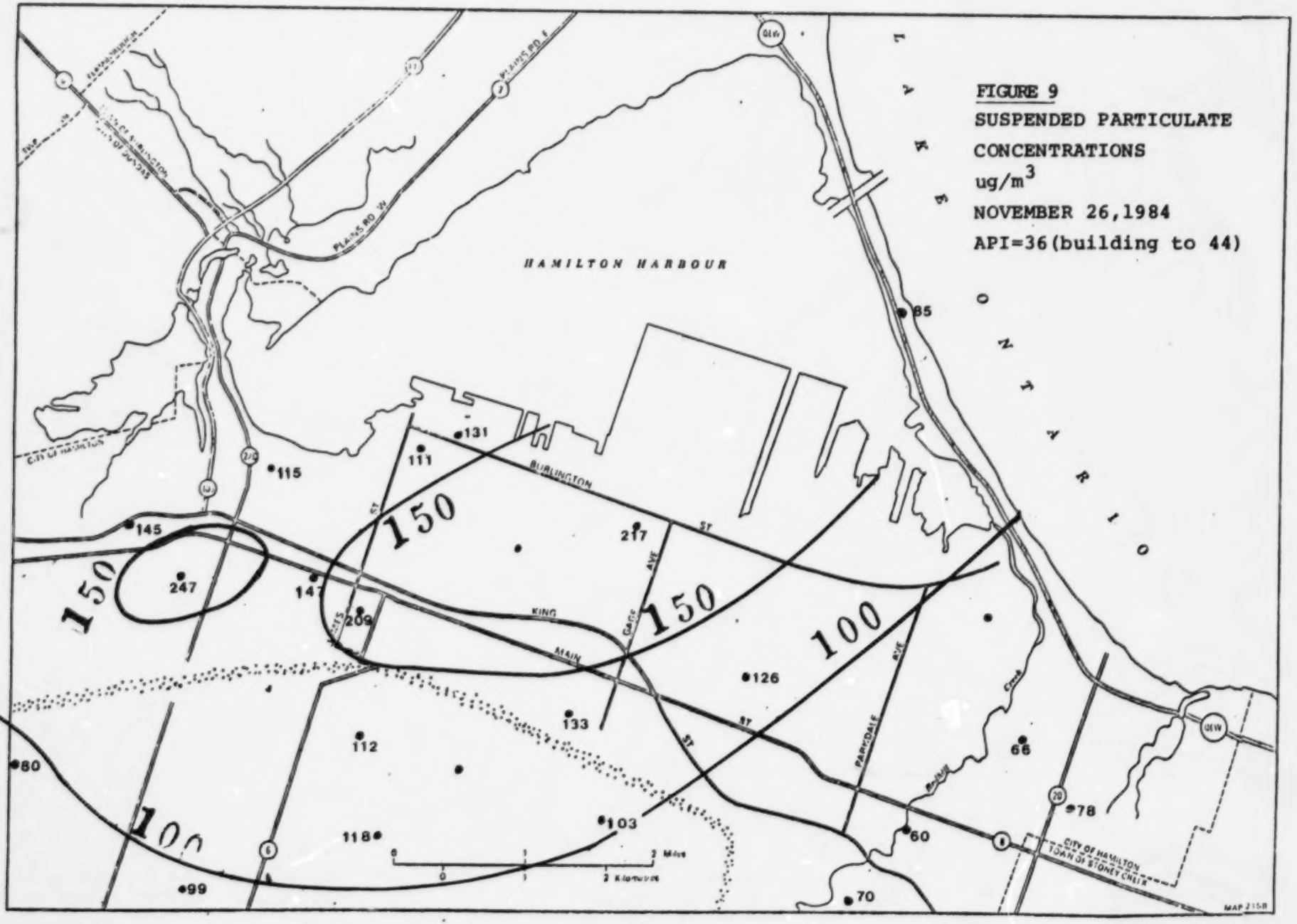


FIGURE 9
SUSPENDED PARTICULATE CONCENTRATIONS
ug/m^3
NOVEMBER 26,1984
API=36(building to 44)

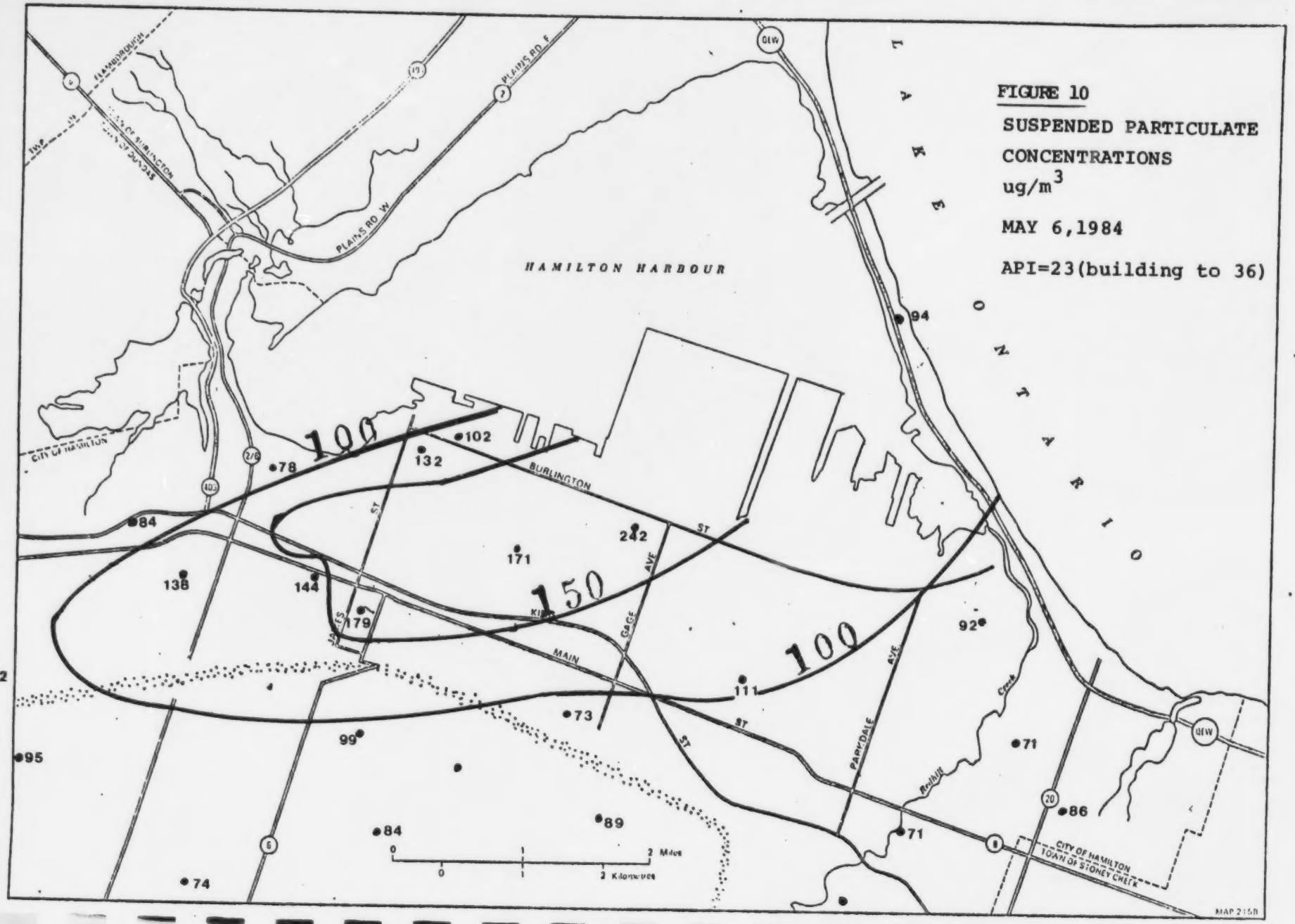


FIGURE 10
SUSPENDED PARTICULATE CONCENTRATIONS
ug/m3
MAY 6,1984
API=23(building to 36)
HAMILTON HARBOUR
LAKE ONTARIO
CITY OF HAMILTON
BURLINGTON ST
MAIN ST
KING ST
GAGE AVE
PARKDALE AVE
PLAINS RD W
PLAINS RD E
QEW
100
150
100
102
132
78
84
138
144
179
171
242
111
73
99
92
95
74
84
89
71
86
94
71
92
2 Miles
2 Kilometres
CITY OF HAMILTON
TOWN OF STONEY CREEK
MAP 2158

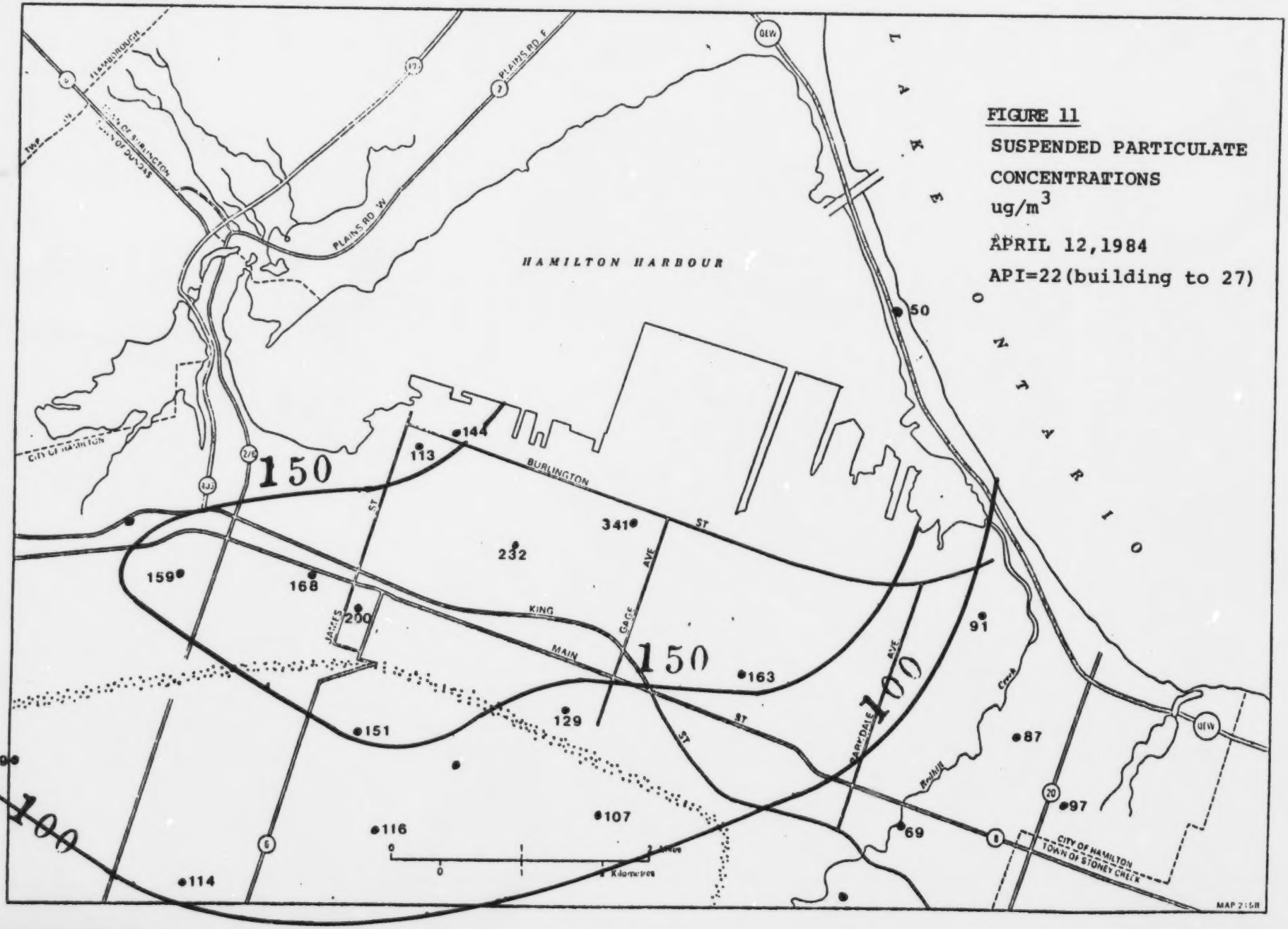


FIGURE 11

SUSPENDED PARTICULATE CONCENTRATIONS ug/m^3

APRIL 12,1984

API=22(building to 27)

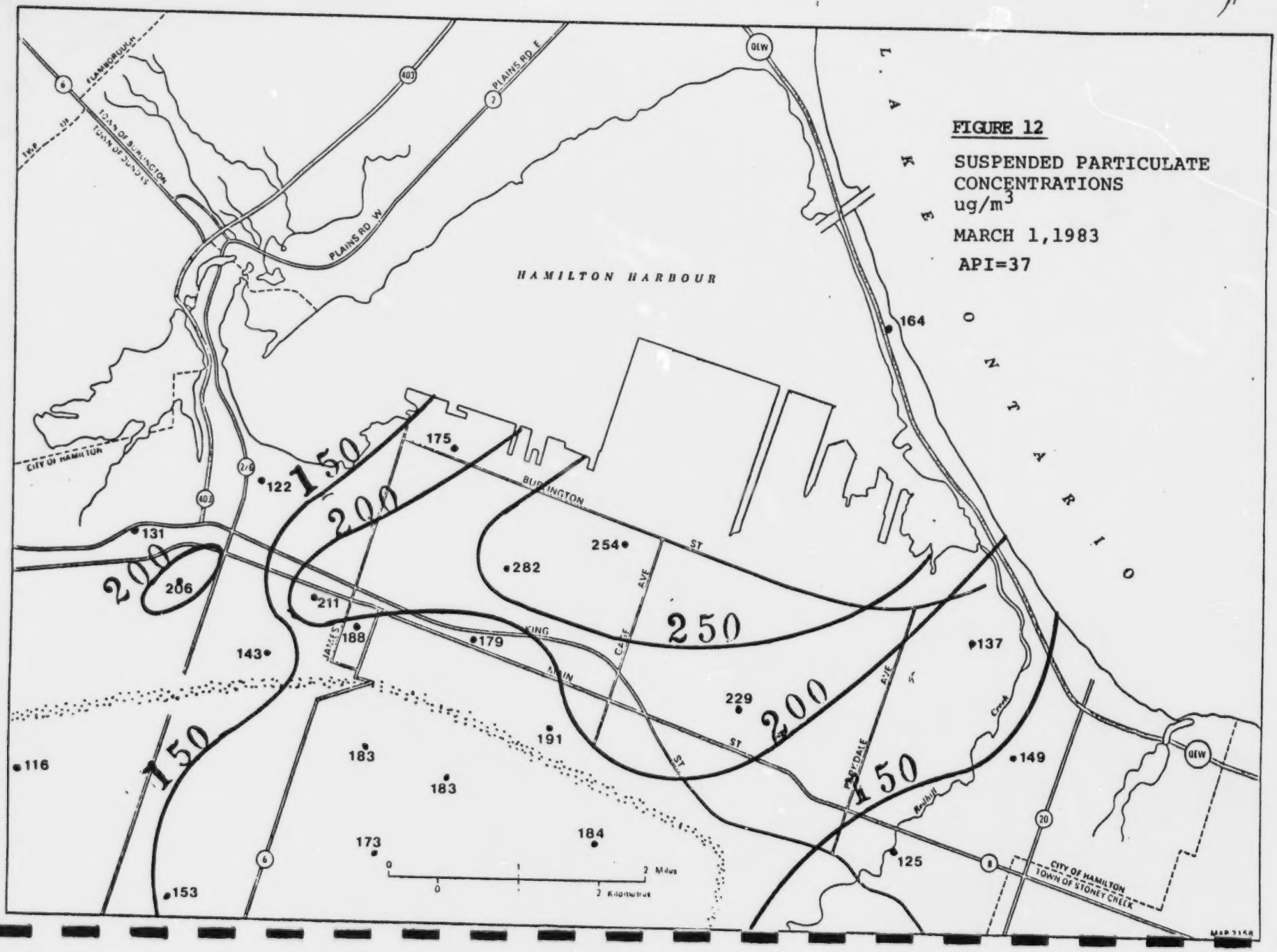
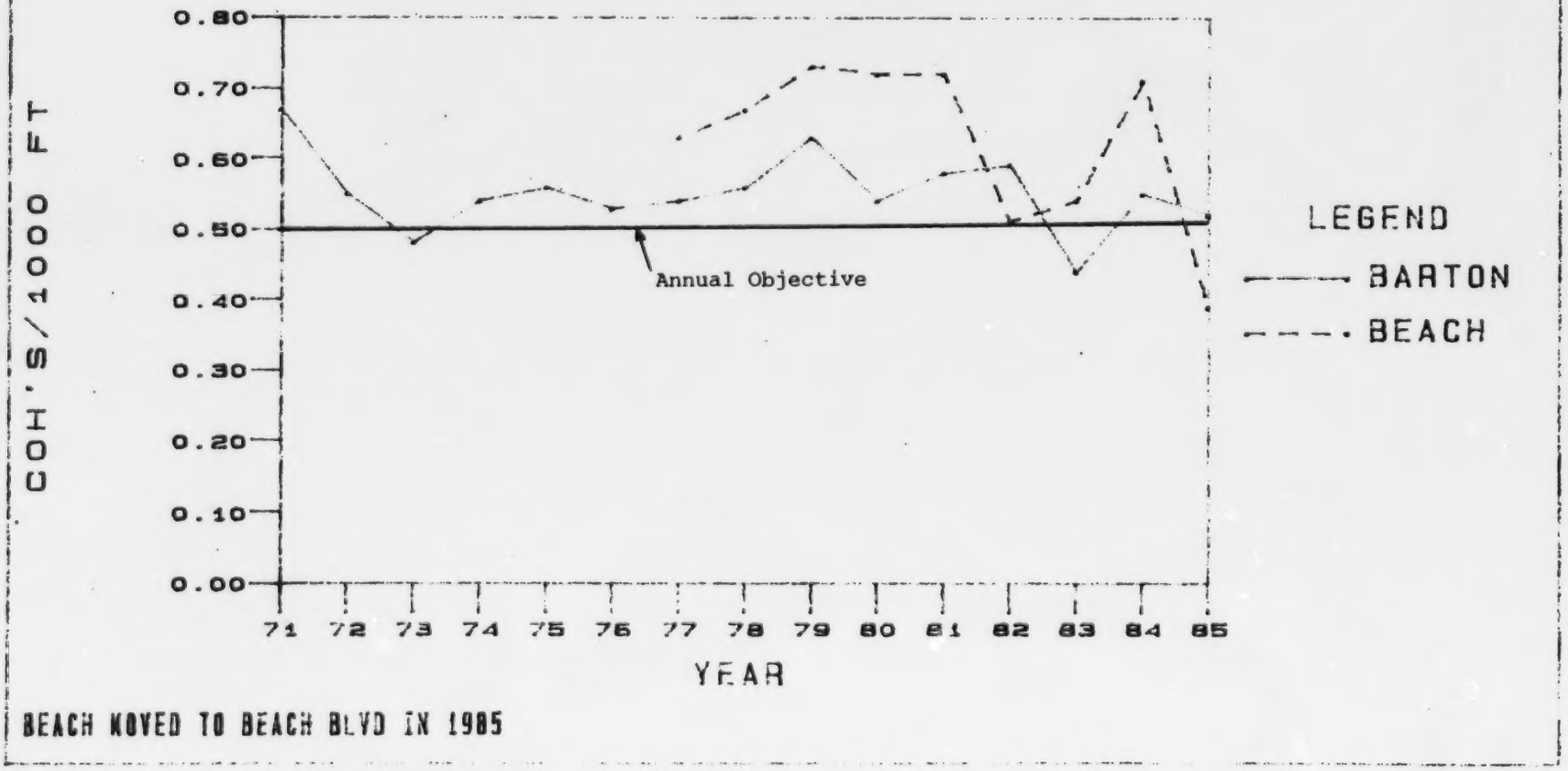


FIGURE 12
SUSPENDED PARTICULATE CONCENTRATIONS
ug/m3
MARCH 1,1983
API=37
HAMILTON HARBOUR
LAKE ONTARIO
PLAINS RD E
PLAINS RD W
BURLINGTON ST
KING ST
MAIN ST
CITY OF HAMILTON
TOWN OF BURLINGTON
TOWN OF DUNDAS
CITY OF HAMILTON
TOWN OF STONEY CREEK
150
200
250
124
131
122
175
164
206
211
188
143
179
254
282
137
229
191
183
183
116
153
173
184
149
125
0 1 2 Miles
0 2 Kilometres

FIGURE 13

SOILING INDEX YEARLY TREND

HAMILTON



BEACH MOVED TO BEACH BLVD IN 1985

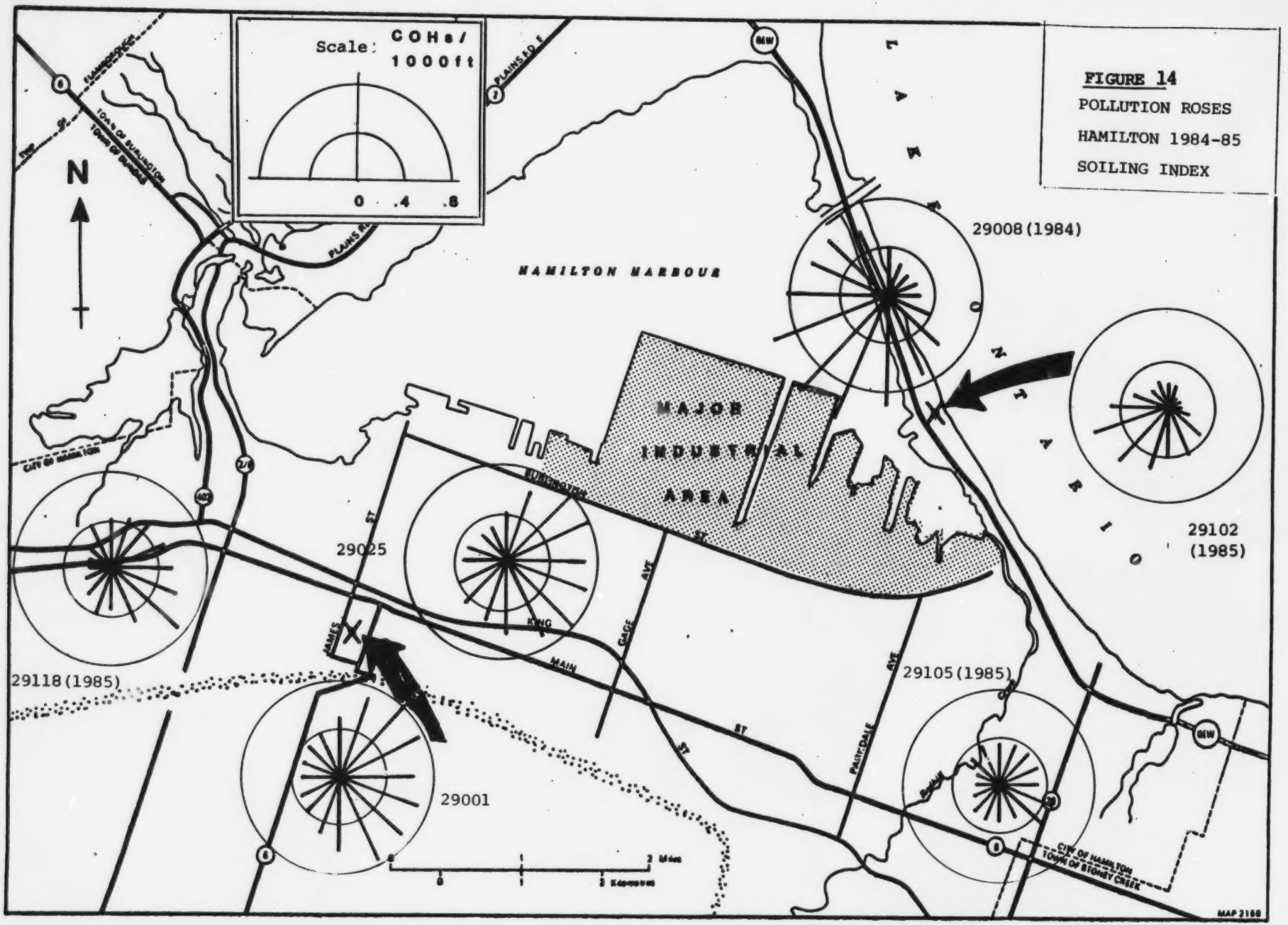


FIGURE 14
POLLUTION ROSES
HAMILTON 1984-85
SOILING INDEX

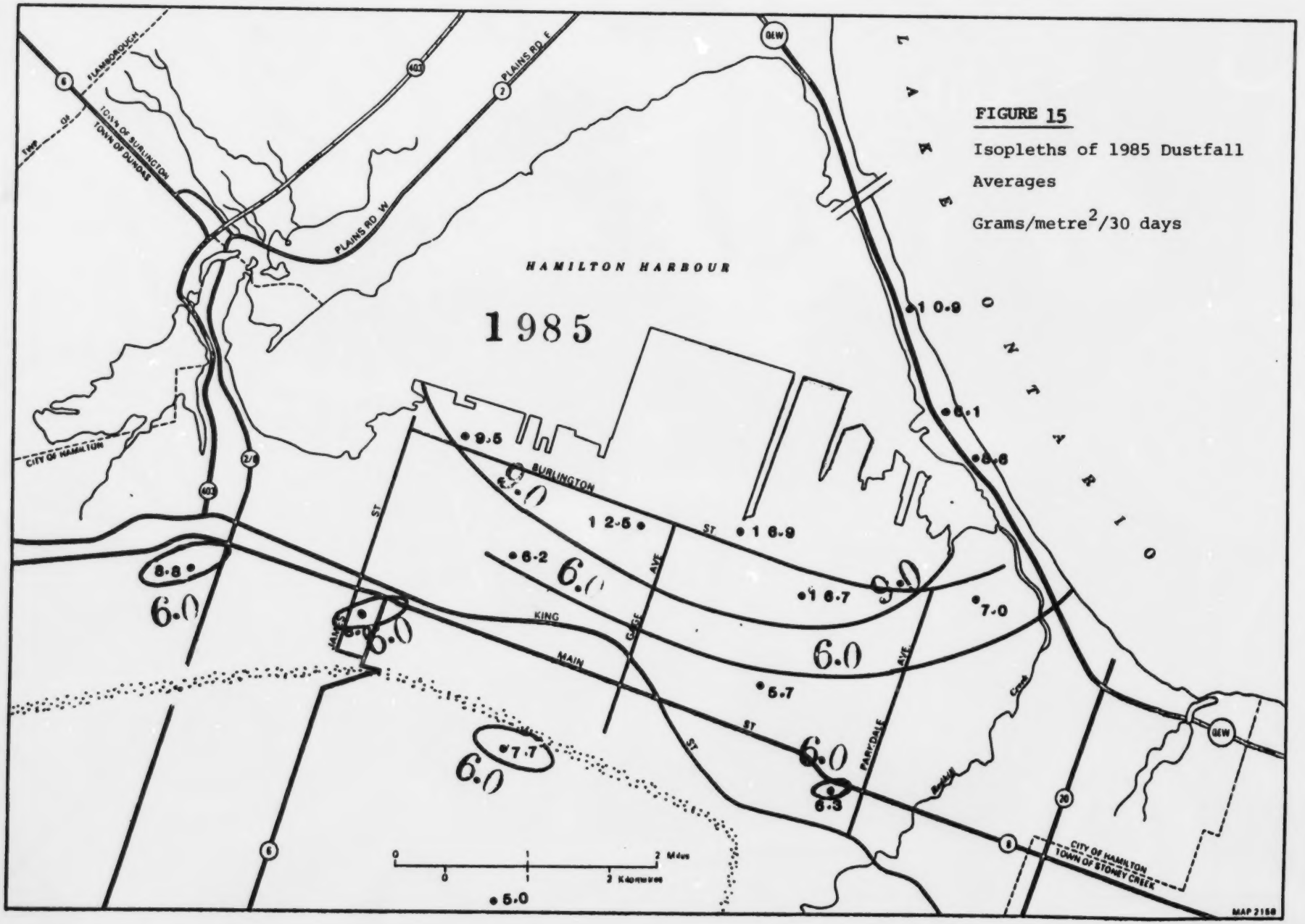


FIGURE 15

Isopleths of 1985 Dustfall Averages

Grams/metre^2/30 days

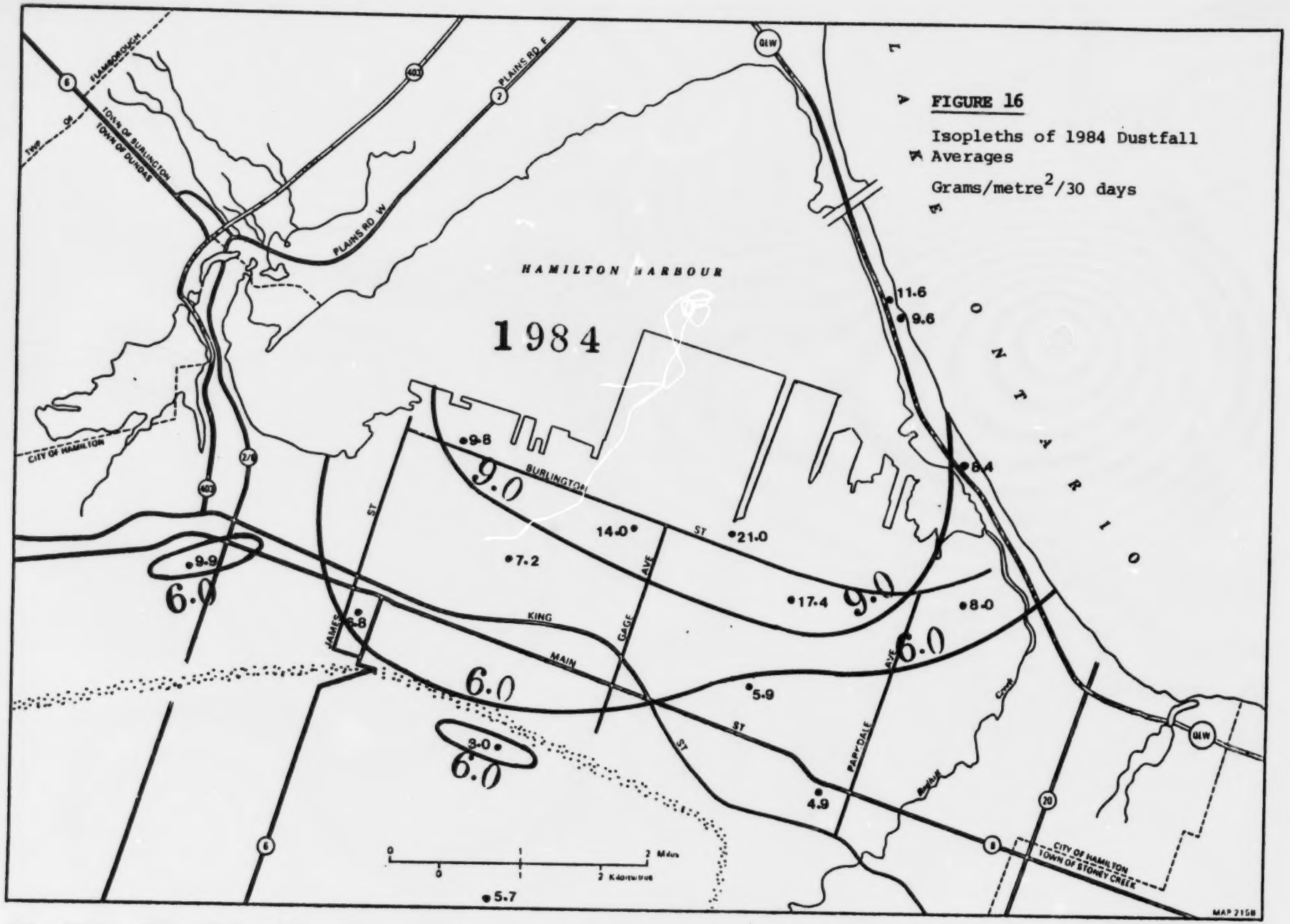
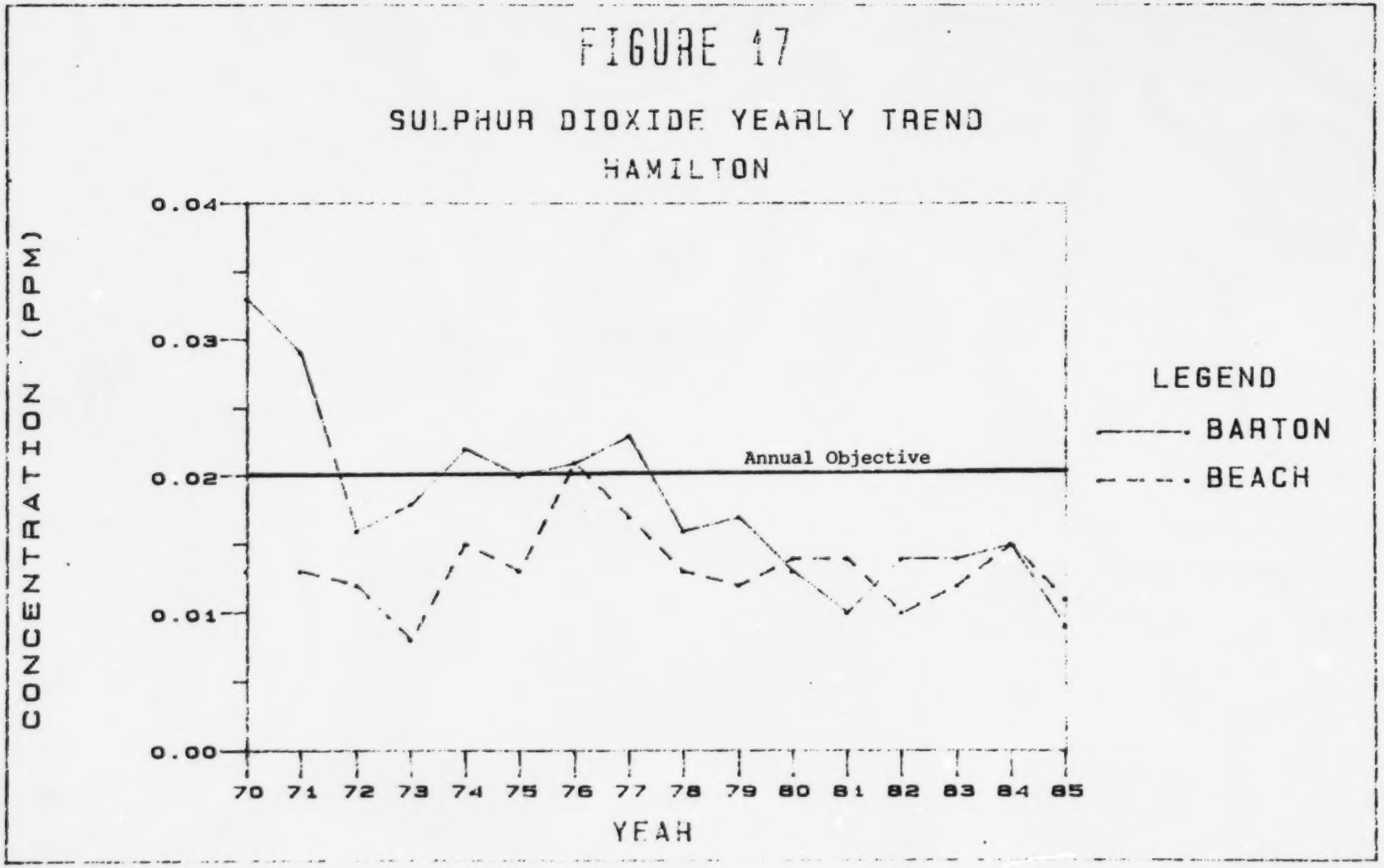


FIGURE 16
Isopleths of 1984 Dustfall Averages
Grams/metre^2/30 days
HAMILTON HARBOUR
1984
LAKE ONTARIO
CITY OF HAMILTON
TOWN OF BURLINGTON
TOWN OF DUNDAS
FLAMBOROUGH
PLAINS RD E
PLAINS RD W
BURLINGTON ST
KING ST
MAIN ST
JAMES ST
GAGE AVE
PARKDALE AVE
CITY OF HAMILTON
TOWN OF STONEY CREEK
9.0
6.0
11.6
9.6
9.8
14.0
21.0
7.2
9.9
6.8
17.4
8.4
8.0
5.9
3.0
4.9
5.7
MAP 2158

FIGURE 17

SULPHUR DIOXIDE YEARLY TREND

HAMILTON



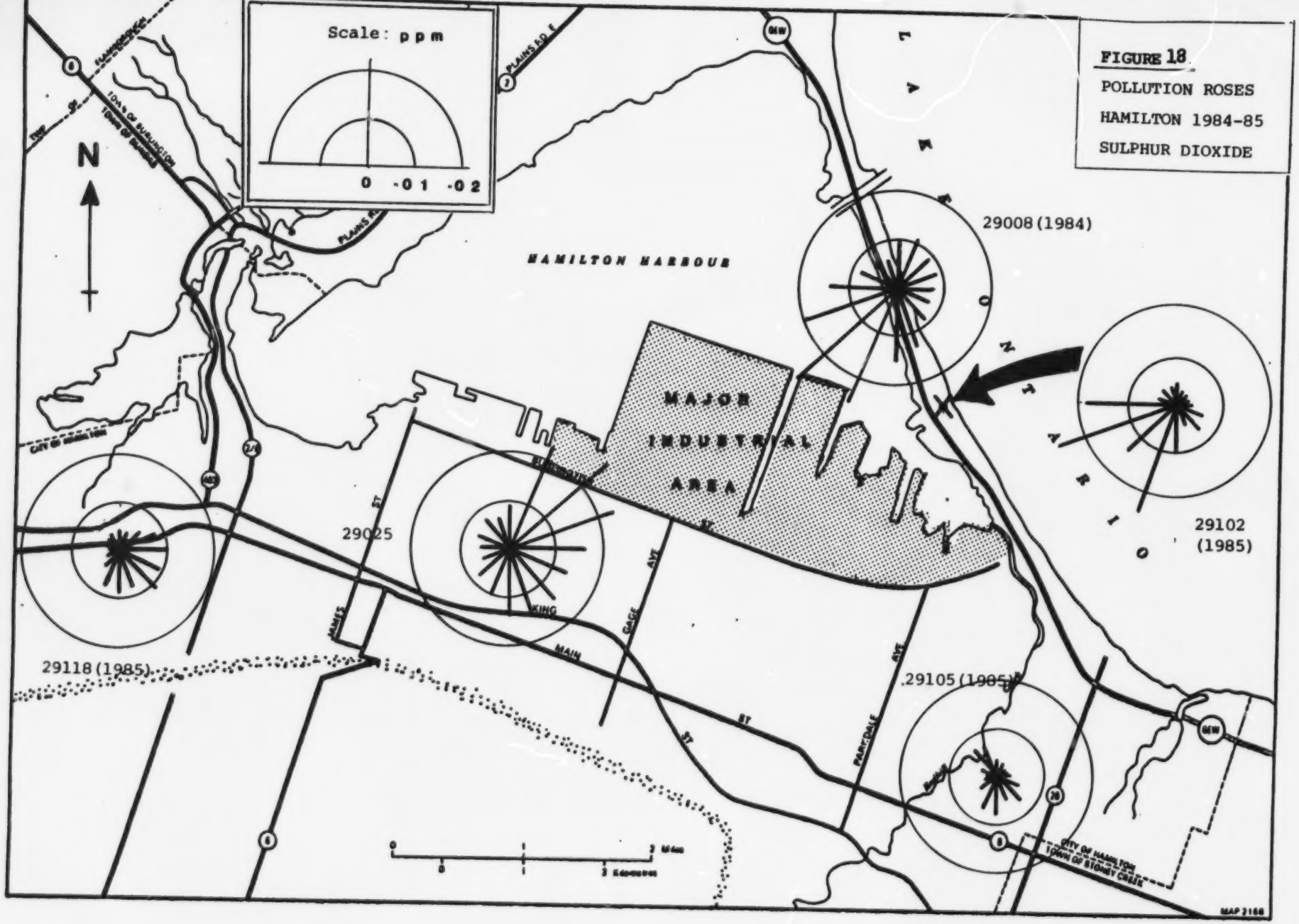
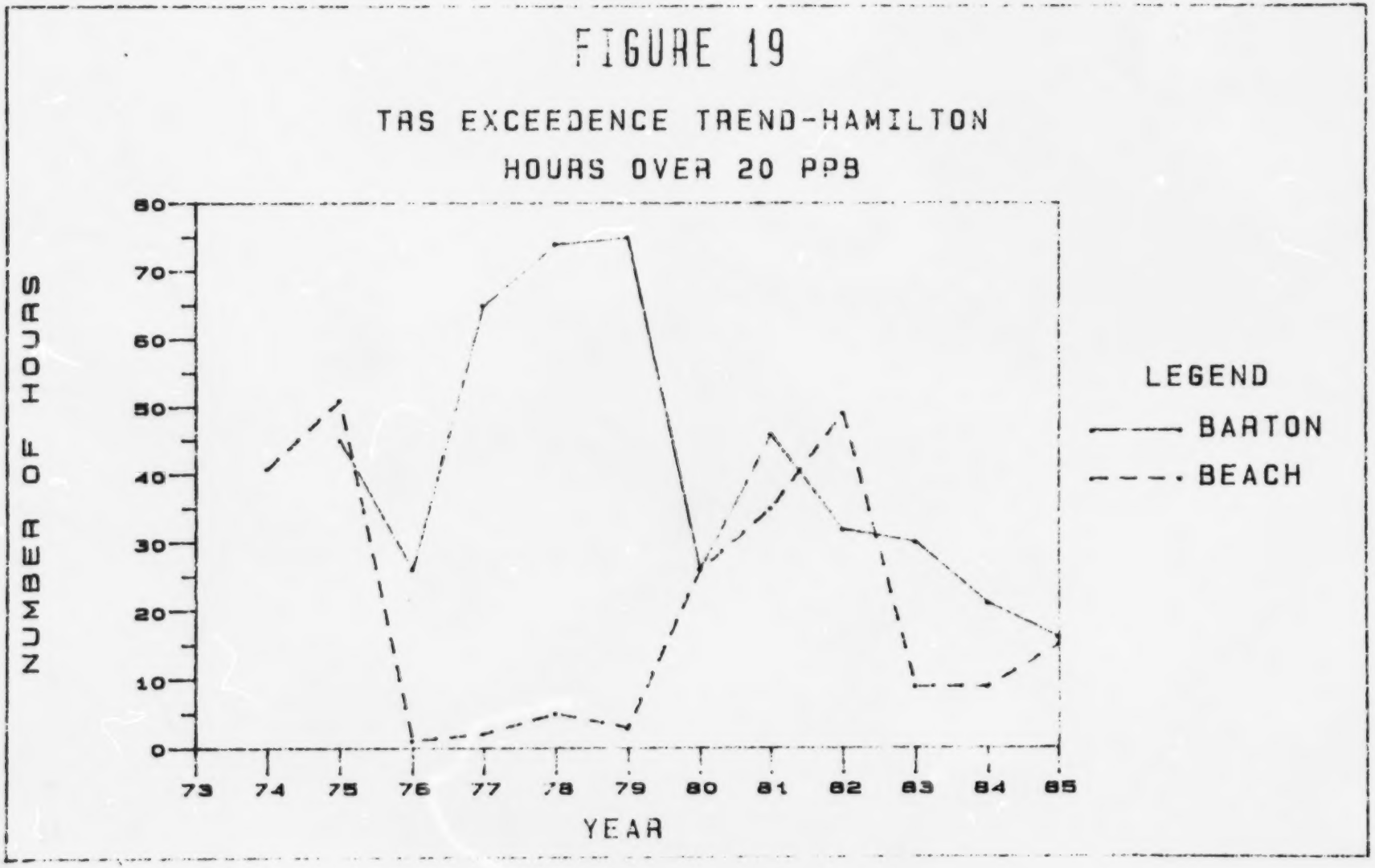


FIGURE 18.
POLLUTION ROSES
HAMILTON 1984-85
SULPHUR DIOXIDE

FIGURE 19


TRS EXCEEDENCE TREND-HAMILTON
HOURS OVER 20 PPB
NUMBER OF HOURS
0
10
20
30
40
50
60
70
80
73
74
75
76
77
78
79
80
81
82
83
84
85
YEAR
LEGEND
BARTON
BEACH

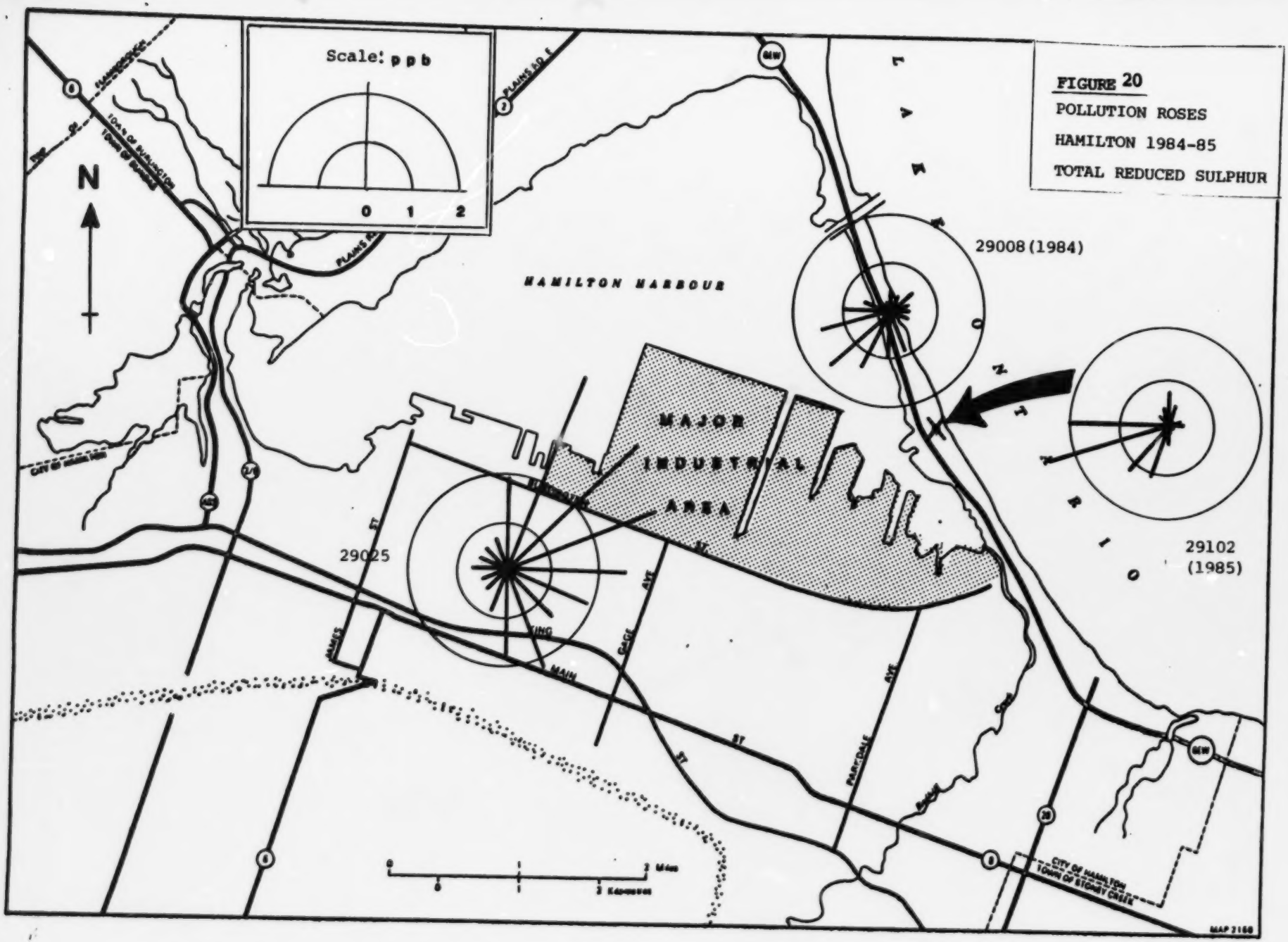
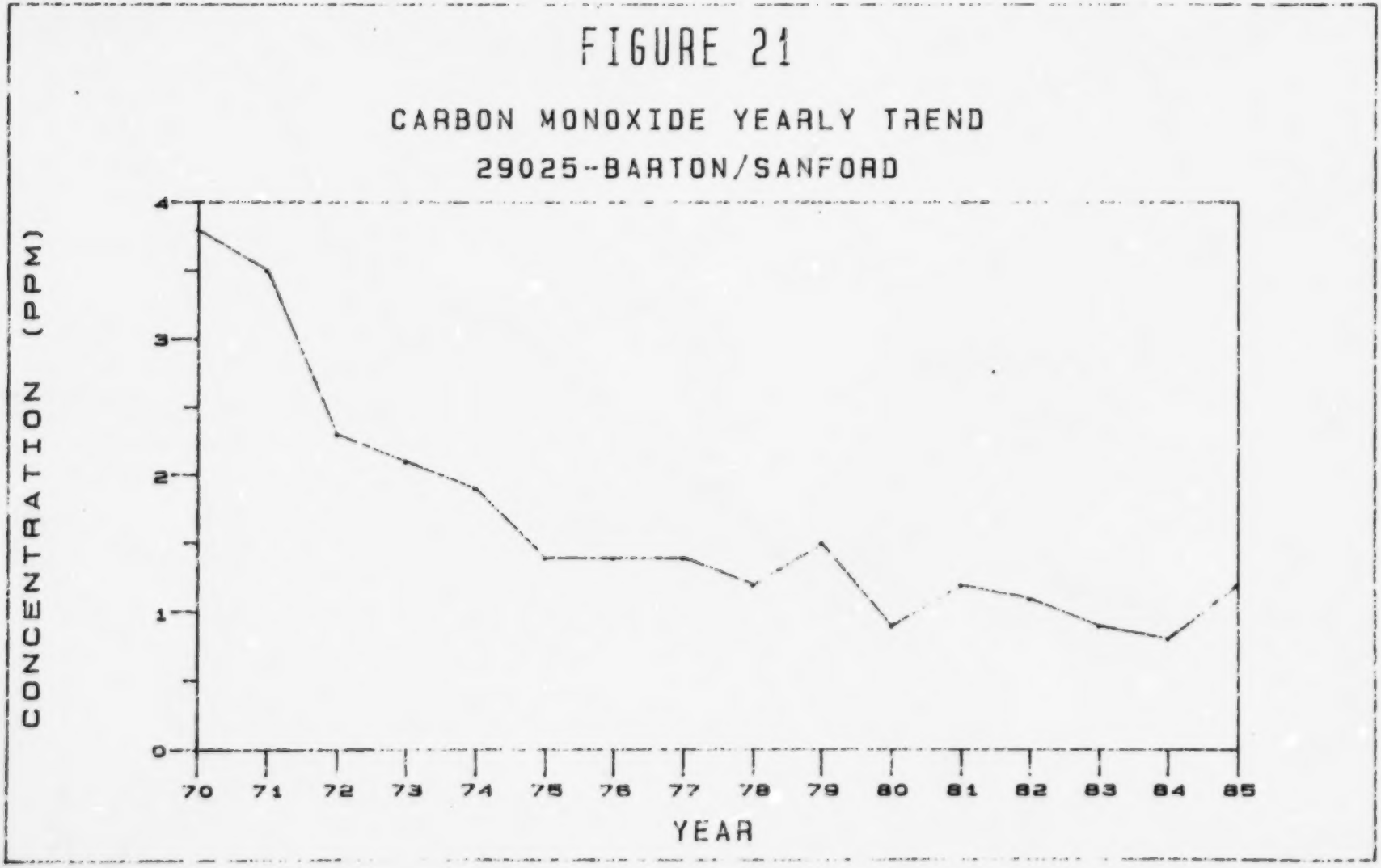

Scale: ppb
0 1 2
N
HAMILTON HARBOUR
MAJOR INDUSTRIAL AREA
29008 (1984)
29025
29102 (1985)
FIGURE 20
POLLUTION ROSES
HAMILTON 1984-85
TOTAL REDUCED SULPHUR

FIGURE 21

CARBON MONOXIDE YEARLY TREND

29025-BARTON/SANFORD



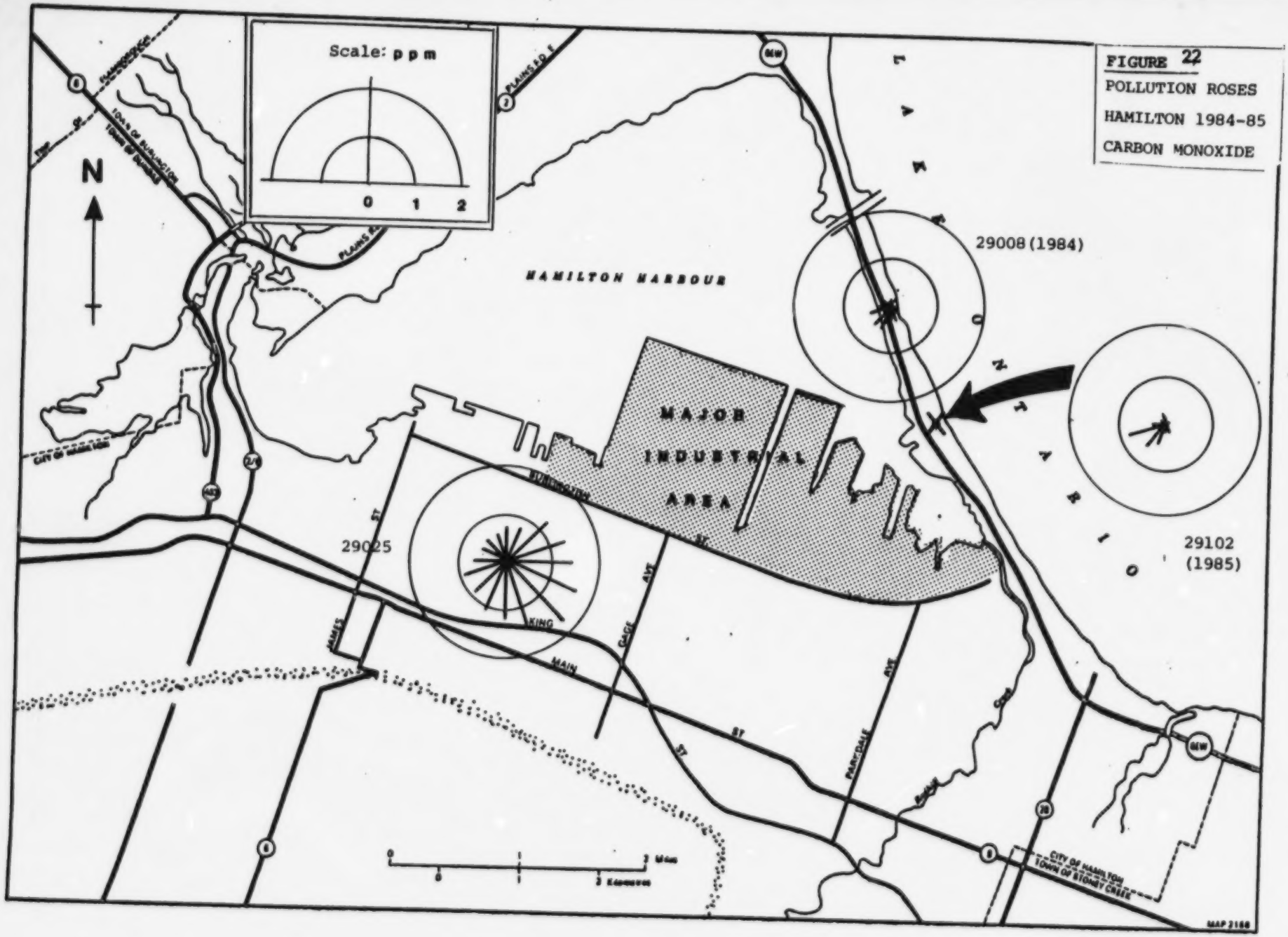
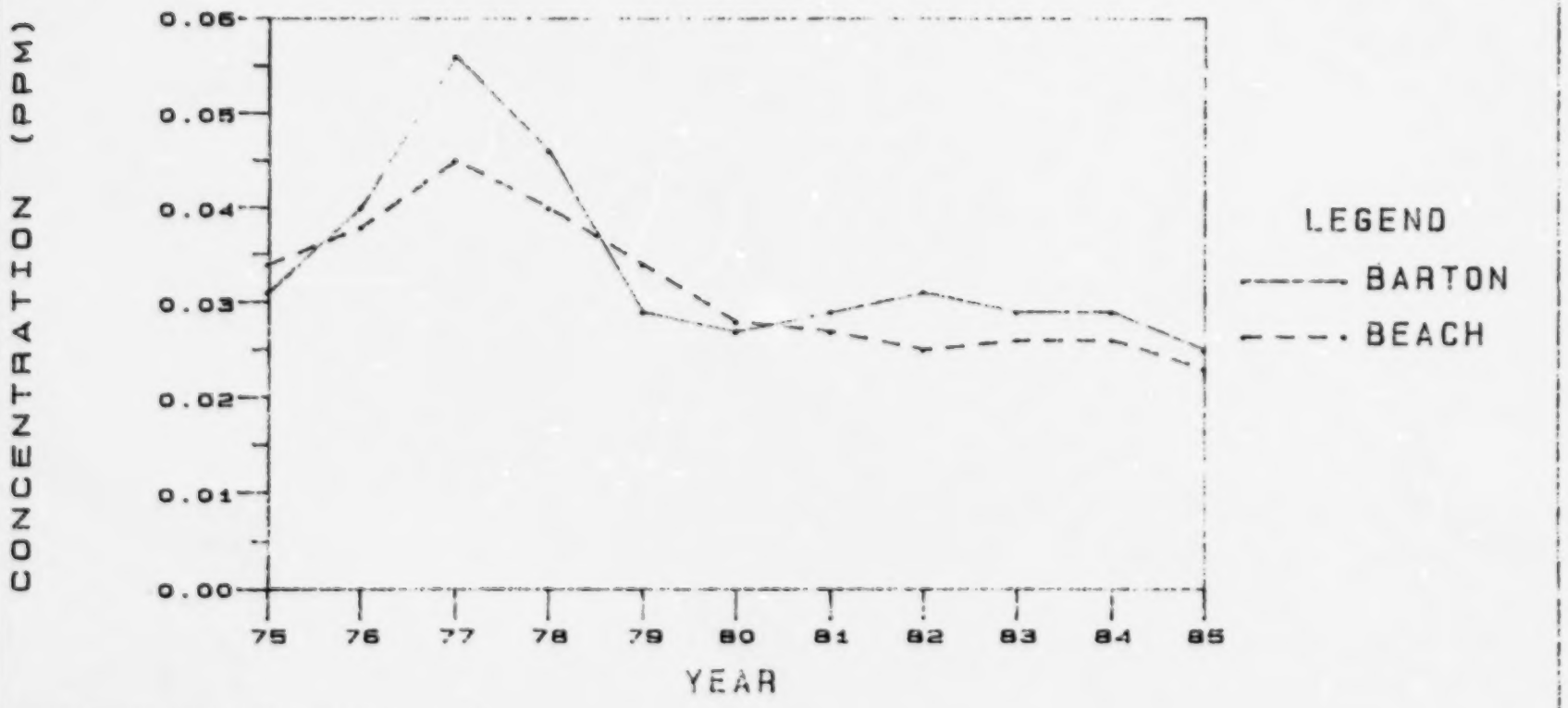


FIGURE 22
POLLUTION ROSES
HAMILTON 1984-85
CARBON MONOXIDE

FIGURE 23

NITROGEN DIOXIDE YEARLY TREND

HAMILTON

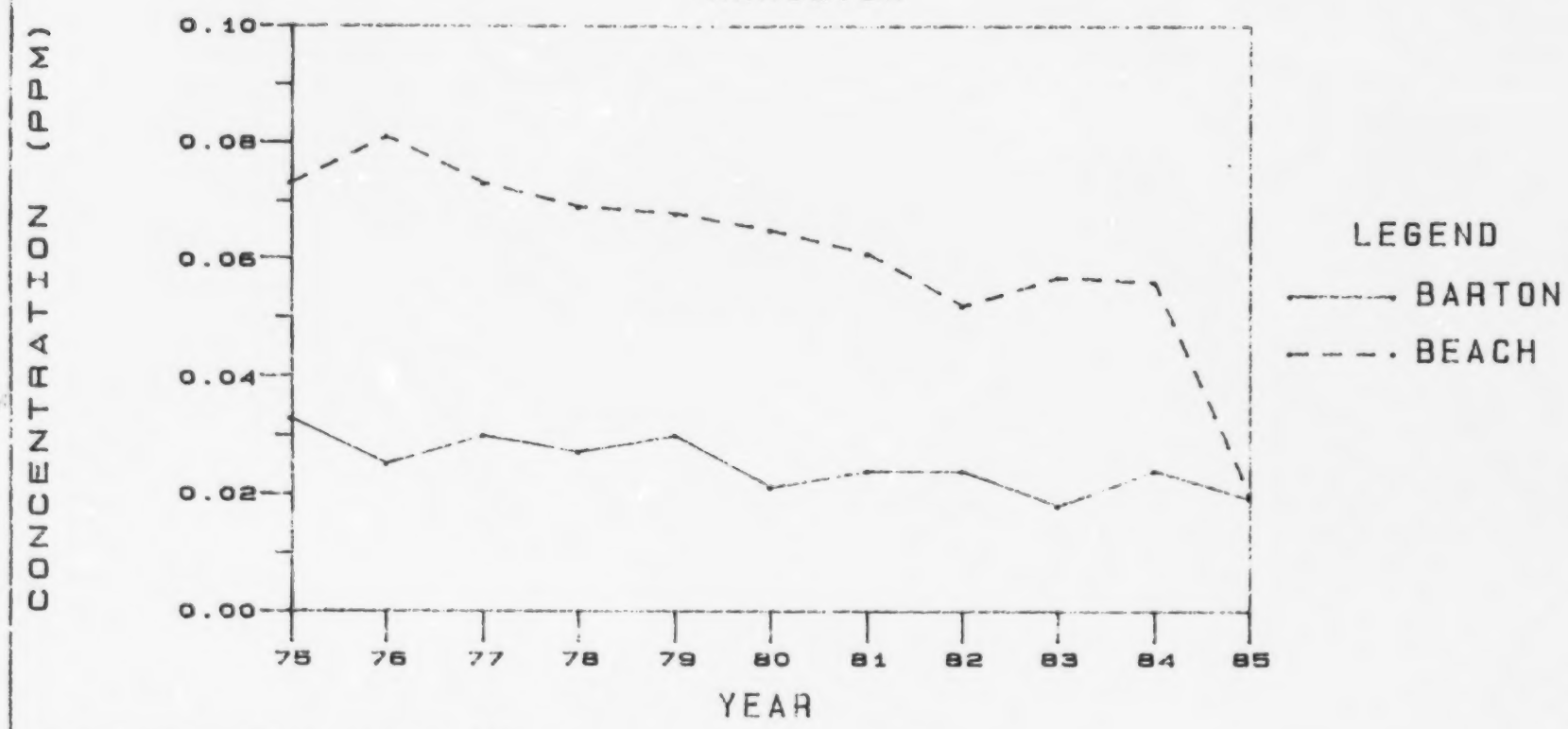


BEACH MOVED TO BEACH BLVD IN 1985

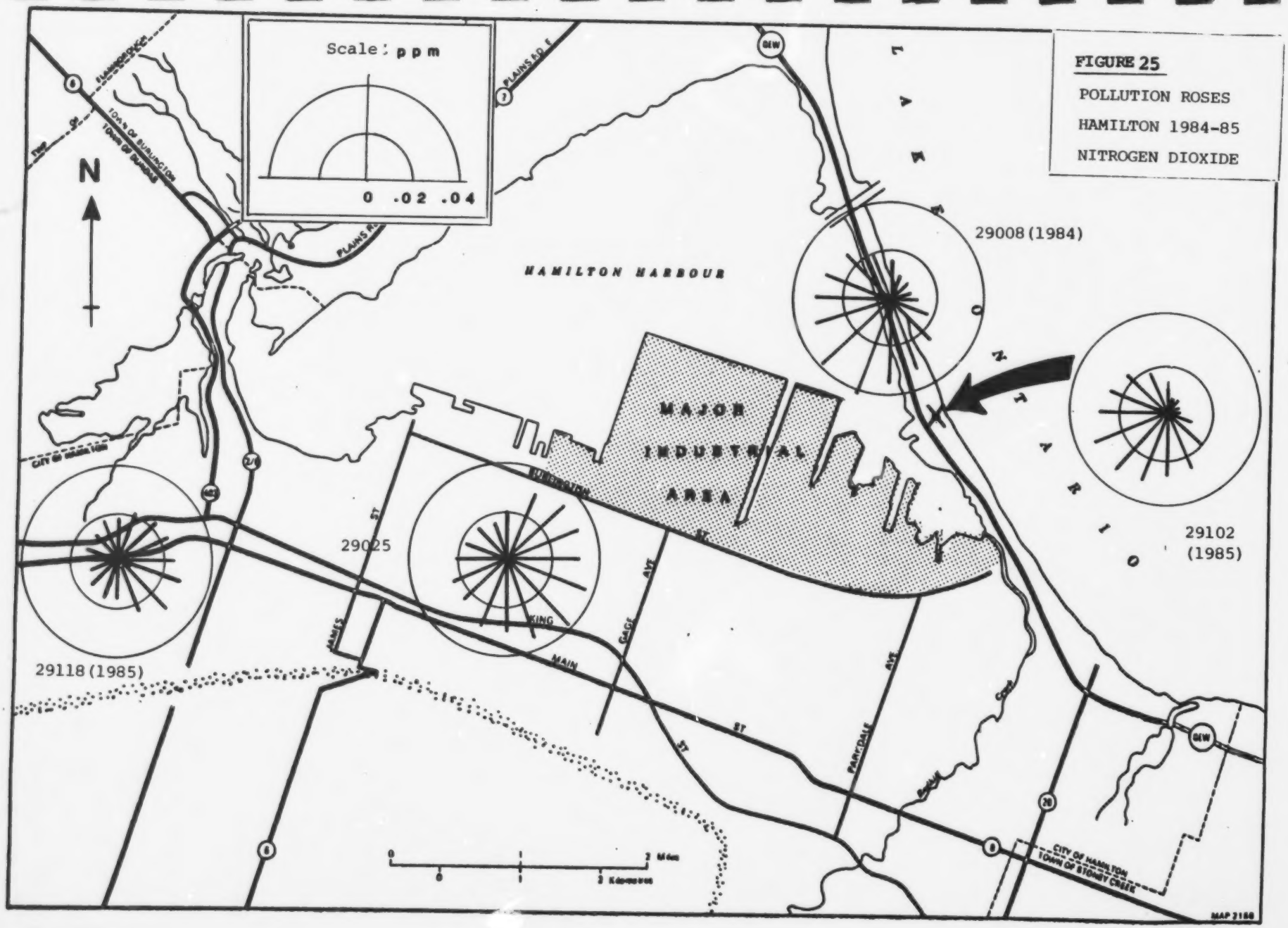
FIGURE 24

NITRIC OXIDE YEARLY TREND

HAMILTON



BEACH MOVED TO BEACH BLVD IN 1985


Scale: ppm
0 .02 .04
N
FIGURE 25
POLLUTION ROSES
HAMILTON 1984-85
NITROGEN DIOXIDE
29008 (1984)
29102 (1985)
29025
29118 (1985)
HAMILTON HARBOUR
MAJOR INDUSTRIAL AREA
ONTARIO
MAIN
KING
CITY OF HAMILTON
TOWN OF STONEY CREEK

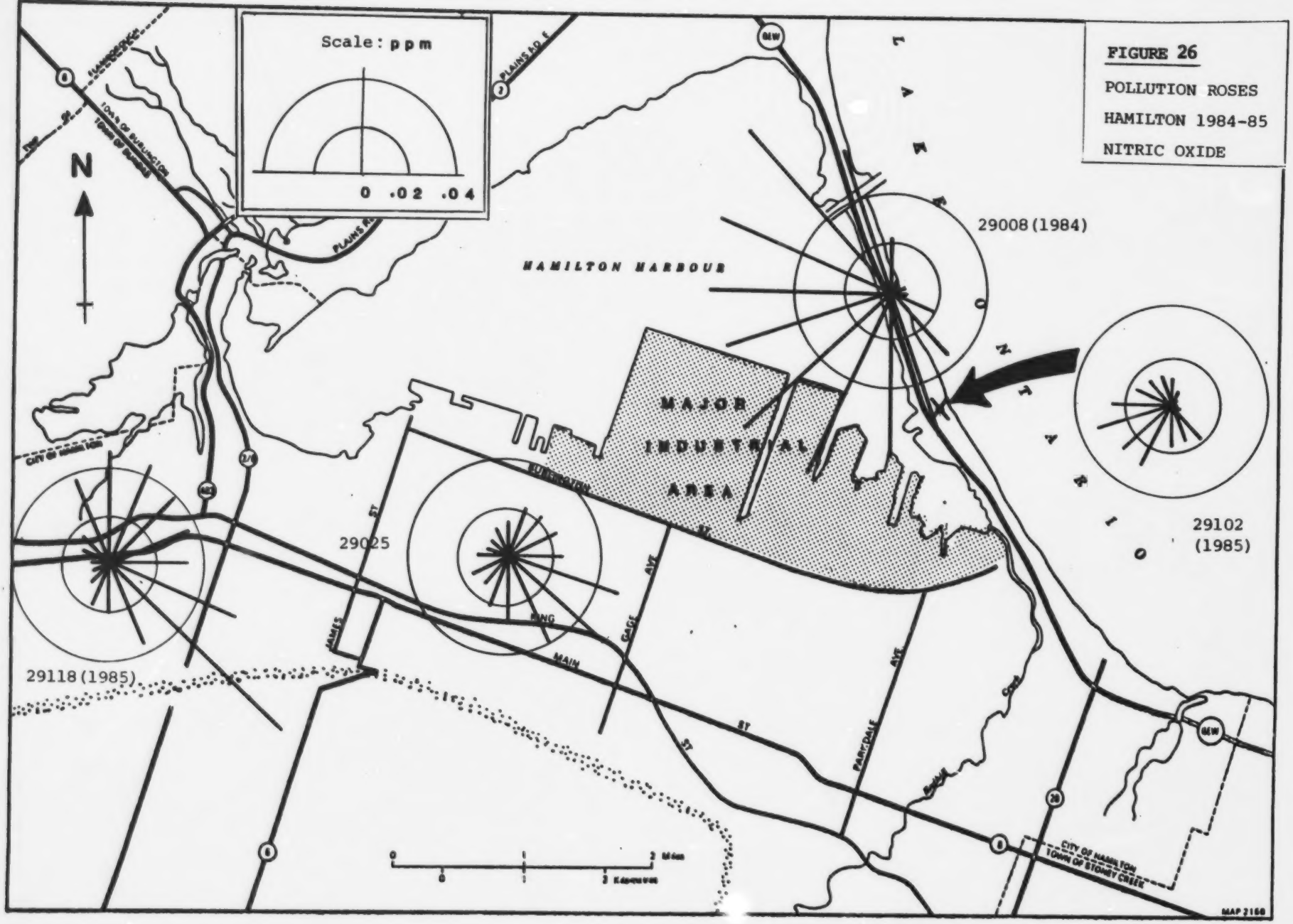


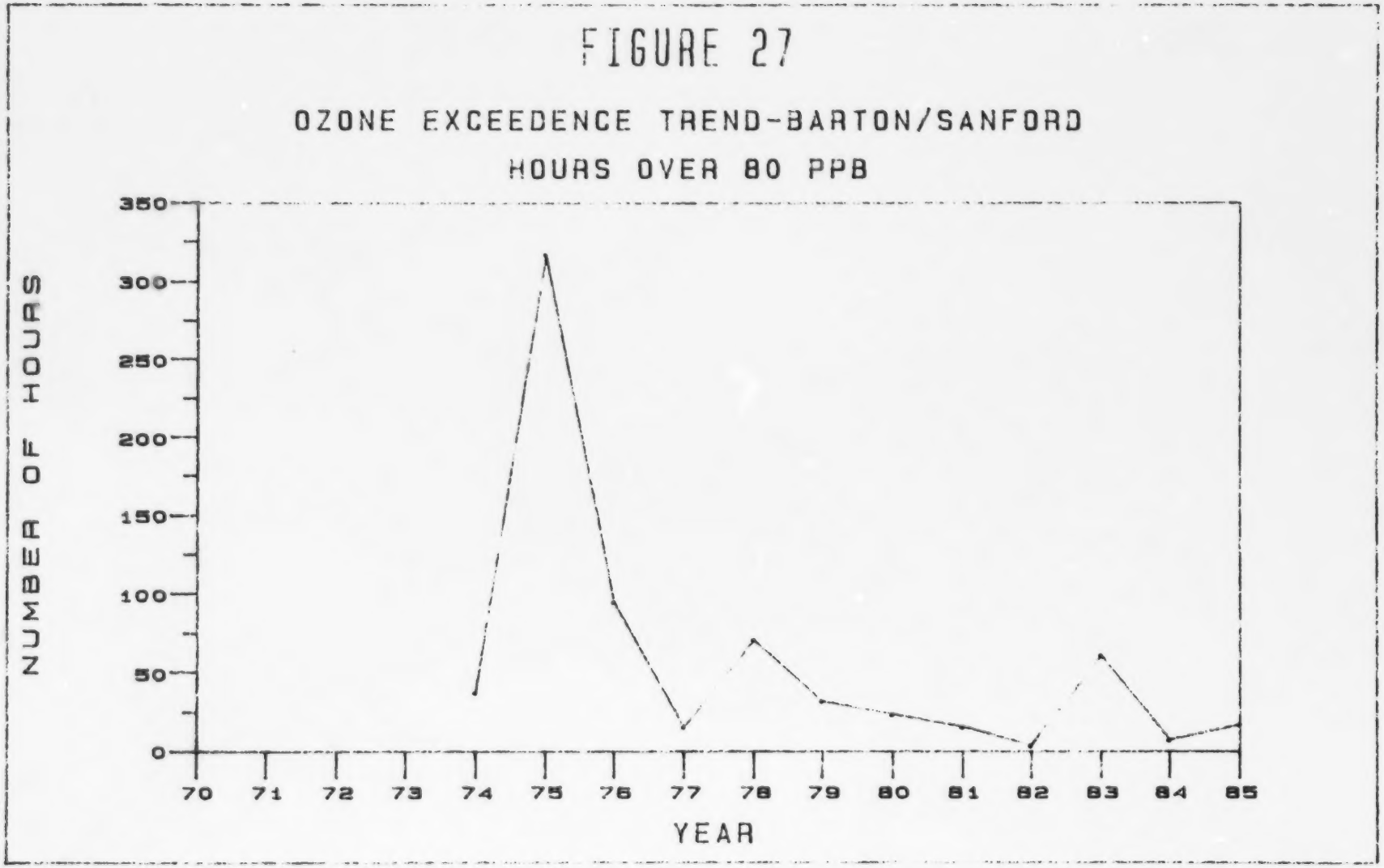
FIGURE 26

POLLUTION ROSES

HAMILTON 1984-85

NITRIC OXIDE

FIGURE 27


OZONE EXCEEDENCE TREND-BARTON/SANFORD
HOURS OVER 80 PPB
NUMBER OF HOURS
350
300
250
200
150
100
50
0
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
YEAR

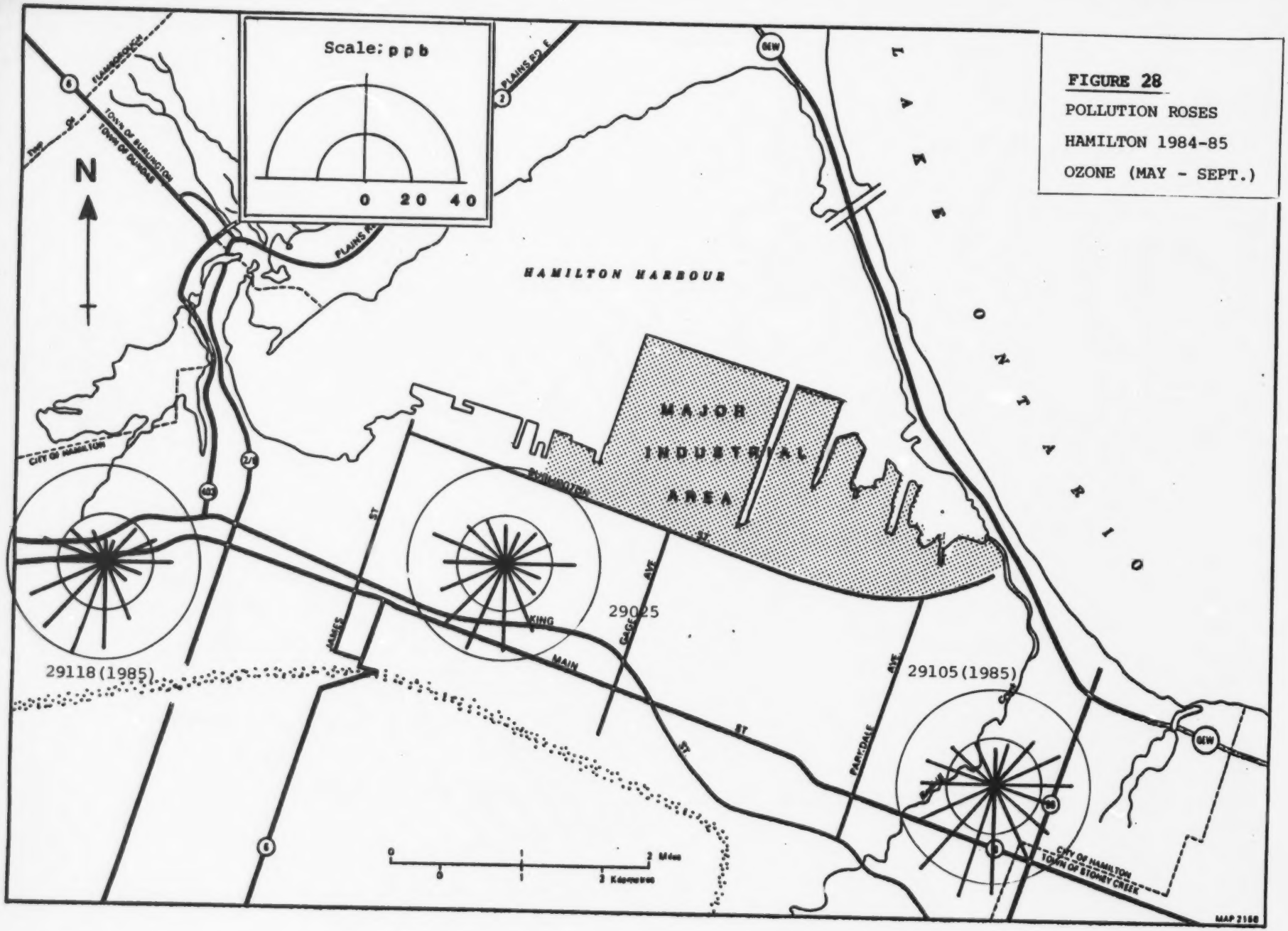


FIGURE 28

POLLUTION ROSES

HAMILTON 1984-85

OZONE (MAY - SEPT.)

FIGURE 29

FLUORIDATION RATE YEARLY TREND

HAMILTON

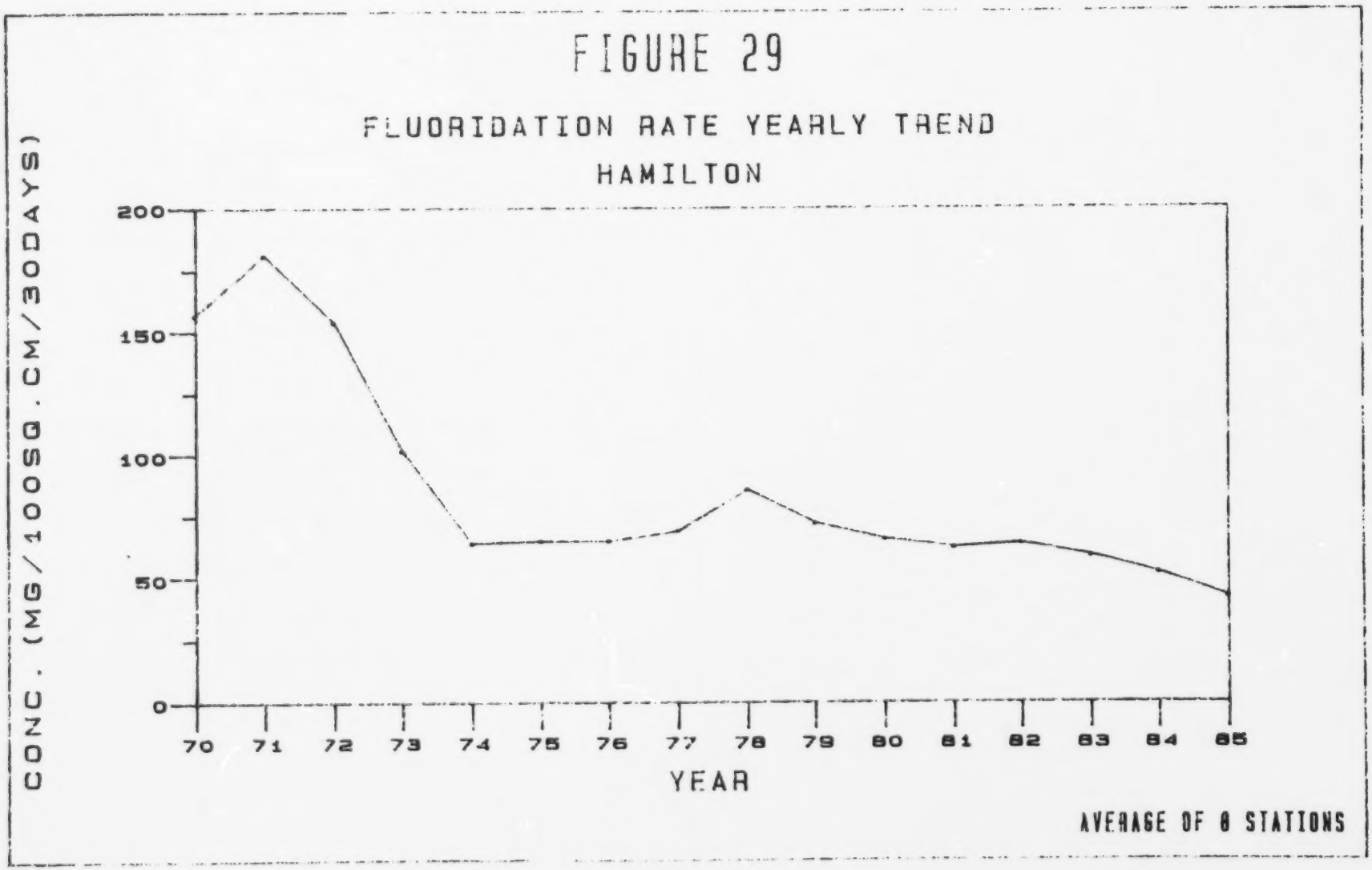


TABLE 1

HAMILTON AIR MONITORING STATION LOCATIONS

NUMBER	LOCATION	AIR POLLUTION INDEX	SULPHUR DIOXIDE	OZONE	CARBON MONOXIDE	OXIDES OF NITROGEN	TOTAL REDUCED SULPHUR	SOILING INDEX	SUSPENDED PARTICULATE	FLUORIDE	DUSTFALL	WIND/TEMP
29001	Hughson/Hunter							X	X	X	X	
29006	Queenston/Craigroyston										X	
29009	Kenilworth/Roxborough								X		X	
29010	Burlington/Ottawa										X	
29011	Burlington/Leeds								X		X	
29012	Burlington/Wellington								X	X	X	
29017	Chatham/Frid								X		X	
29025	Barton/Sanford	X	X	X	X	X	X	X	X	X	X	
29026	Woodward/Brampton											X
29030	Camden/Mohawk										X	
29031	Concession/Up. Sherman										X	
29036	Roosevelt/Beach Road										X	
29044	Wark/Beach Blvd.										X	

TABLE 1 (cont.)

HAMILTON AIR MONITORING STATION LOCATIONS

NUMBER	LOCATION	AIR POLLUTION INDEX	SULPHUR DIOXIDE	OZONE	CARBON MONOXIDE	OXIDES OF NITROGEN	TOTAL REDUCED SULPHUR	BOILING INDEX	SUSPENDED PARTICULATE	FLUORIDE	DUSTFALL	WIND/TEMP
29054	Beach Road/Conrad									X		
29058	QEW Arden									X		
29059	Burlington/Gage									X		
29062	King E./Barons									X		
29066	Killarney/Beach Blvd.									X		
29067	Hughson N./Macaulay								X			
29082	Leaside/Knox										X	
29084	Rembe/Beach Blvd.										X	
29085	Up. Wellington/Inverness								X			
29087	Cumberland/Prospect								X			
29089	Barton/Nash								X			
29090	King W./South Oval								X			
29098	Bay/Main West								X			

TABLE 1 (cont.)

HAMILTON AIR MONITORING STATION LOCATIONS

NUMBER	LOCATION	AIR POLLUTION INDEX	SULPHUR DIOXIDE	OZONE	CARBON MONOXIDE	OXIDES OF NITROGEN	TOTAL REDUCED SULPHUR	SOILING INDEX	SUSPENDED PARTICULATE	FLUORIDE	DUSTFALL	WIND/TEMP
29102 (29008)	Beach Blvd./Towers North Park		X		X	X	X	X	X		X	
29105	Nash/Kentley		X	X				X				
29114	Vickers/East 18th (1986)		X	X				X				
29118	Main W./Highway 403		X	X		X		X	X			

TABLE 2

AIR POLLUTION INDEX - 1984-85

OCCASIONS WHEN 32 OR ABOVE

Date	No. of Hours ≥ 32	Maximum
1984		
1. January 16	9	33
2. February 13-14	16	33
3. May 7-8	27	36
4. October 11-13	26	34
5. October 17	8	33
6. October 19	1	32
7. October 30	2	32
8. November 26-28	35	44
9. December 10-11	29	38
1985		
1. April 23-24	24	36
2. November 13	4	32

NUMBER OF INCIDENTS AND HOURS ABOVE 31

	Number	Hours	Maximum
1985	2	28	36
1984	9	153	44
1983	1	26	37
1982	13	203	39
1981	8	118	38
1980	5	71	40
1979	22	485	55
1978	7	93	43
1977	9	201	44

TABLE 3a

SUSPENDED PARTICULATES - 1984-85
UNIT - MICROGRAMS PER CUBIC METER
unless otherwise specified

ONTARIO OBJECTIVES: 24 hour - 120
1-year Geo. Mean - 60

LOCATION	Geometric Mean 1983	1984	1985	Maximum 1984	1985	%of Samples Above 120 1984	1985
29001 - Hughson/Hunter	64	75	55	209	150	11	2
29008 - North Park	73	89	-	339	-	32	-
29009 - Kenilworth/Roxborough	55	63	56	316	142	5	3
29011 - Burlington/Leeds	95	102	113	365	270	25	52
29012 - Burlington/Wellington	68	80	83	237	232	18	31
29017 - Chatham/Frid	80	87	61	356	212	24	12
29025 - Barton/Sanford	75	81	71	332	253	21	15
29067 - 450 Hughson St. N.	47	58	52	320	124	5	2
29085 - Mountain Police Station	53	53	41	224	135	3	5
29087 - Cumberland/Prospect	61	59	56	333	164	5	4
29089 - Barton/Nash	57	57	55	131	111	2	0
29090 - Westdale Library/ 29118 - Main West	50	65	47*	249	131	4	2
29098 - Bay/Main	61	55	42	168	113	9	0
29102 - Beach Blvd.	-	-	69	-	324	-	21

*Combined mean of two locations. Station moved to 29118 in July 1985.

TABLE 3b

MCMASTER UNIVERSITY SAMPLING - 1984-85

SUSPENDED PARTICULATES

UNIT MICROGRAMS PER CUBIC METER
unless otherwise specified

ONTARIO OBJECTIVES: 24-hour average - 120
1-year Geo. Mean - 60

LOCATION	Geometric Mean 1983	1984	1985	Maximum 1984	1985	%of Samples Above 120 1984	1985
San Diego Court	42	45	41	442	148	2	2
Upper Ottawa/Mohawk	39	39	36	413	117	2	0
Whitney/Rifle Range	40	44	38	379	146	2	2
Pottruff/Queenston	40	39	37	377	126	2	2
McElroy/Upper Wellington	49	51	58	315	148	2	4
Queensdale/Green Meadow	54	54	45	323	158	2	2
Westmount	44	45	39	449	128	2	2
Bishopgate/Ranchdale	45	47	40	462	131	2	2
Dundurn Castle	43	49	41	291	157	2	2
Centennial Pkwy./Violet Drive	54	61	52	417	108	2	0
Woodward/Brampton	58	67	52	307	157	4	2
Mt. Albion/Albright	-	-	38	-	106	-	0

TABLE 3c CONSTITUENTS IN SUSPENDED PARTICULATE (ug/m^3)

	Criterion: 2.0(24 Hours)									Criterion: 5.0(24 Hours)					
	CADMIUM			CHROMIUM			IRON			LEAD			MANGANESE		
Station and Year	# of Samples	Geo. Mean	Max.	# of Samples	Geo. Mean	Max.	# of Samples	Geo. Mean	Max.	# of Samples	Geo. Mean	Max.	# of Samples	Geo. Mean	Max.
29001															
1982	55	.001	.008	55	.004	.039	52	1.2	17.8	52	0.3	1.1	55	.08	.62
1983	55	.001	.028	55	.004	.039	55	1.4	13.2	55	0.3	1.4	55	.06	.70
1984	57	.002	.006	57	.001	.060	57	1.9	11.4	57	0.4	1.1	57	.10	.83
1985	57	.001	.004	57	.001	.073	57	1.5	11.1	57	0.2	0.5	57	.09	.57
29008/29102															
1982	330	.001	.005	327	.006	.091	309	2.7	16.3	338	0.4	1.8	330	.15	.89
1983	337	.001	.006	337	.004	.045	337	2.4	15.4	330	0.4	2.4	337	.15	.98
1984	51	.001	.005	51	.007	.056	51	3.1	13.9	51	0.4	1.2	51	.21	.92
1985*	52	.001	.004	52	.002	.037	52	2.5	12.2	52	0.1	0.5	52	.18	.81
29011															
1982	57	.001	.016	57	.014	.078	57	3.8	42.0	54	0.3	1.7	57	.21	1.54
1983	54	.001	.004	54	.013	.056	54	4.5	19.3	54	0.3	1.0	54	.28	.98
1984	59	.002	.015	59	.013	.219	59	5.1	18.3	59	0.4	0.9	59	.34	1.48
1985	58	.002	.005	58	.020	.092	58	5.7	23.2	58	0.3	0.7	58	.40	2.16
29012															
1982	59	.001	.012	58	.008	.051	58	1.7	11.5	55	0.3	1.1	59	.11	.55
1983	52	.001	.005	52	.003	.028	52	1.6	9.9	52	0.2	1.2	52	.10	.61
1984	57	.001	.010	57	.002	.038	57	1.9	10.2	57	0.3	0.8	57	.11	.43
1985	58	.001	.022	58	.002	.052	58	2.1	6.0	58	0.2	0.5	58	.16	1.29

*29008 moved to 29102 in 1985.

TABLE 3c CONSTITUENTS IN SUSPENDED PARTICULATE (ug/m^3)

	Criterion: 2.0(24 Hours)									Criterion: 5.0(24 Hours)					
	CADMIUM			CHROMIUM			IRON			LEAD			MANGANESE		
Station and Year	# of Samples	Geo. Mean	Max.	# of Samples	Geo. Mean	Max.	# of Samples	Geo. Mean	Max.	# of Samples	Geo. Mean	Max.	# of Samples	Geo. Mean	Max.
29017															
1982	59	.001	.009	59	.005	.047	52	2.1	19.5	58	0.3	3.0	59	.09	.76
1983	56	.001	.004	56	.004	.027	56	2.0	8.4	57	0.2	1.8	56	.10	.43
1984	57	.001	.003	57	.003	.033	57	2.2	9.1	57	0.3	1.9	57	.11	.77
1985	57	.001	.003	57	.001	.036	57	1.7	6.2	57	0.2	0.4	57	.09	.49
29025															
1982	325	.001	.026	325	.008	.093	296	2.6	27.9	301	0.4	2.3	325	.14	1.22
1983	328	.001	.020	327	.005	.100	328	2.2	15.3	328	0.3	2.5	328	.13	1.49
1984	57	.002	.011	57	.004	.073	57	3.1	22.5	57	0.4	2.2	57	.18	1.42
1985	51	.001	.006	51	.004	.309	51	1.5	14.9	51	0.3	1.1	51	.19	1.74
29067															
1982	45	.001	.008	45	.007	.088	43	1.4	8.5	43	0.2	1.2	45	.09	.84
1983	56	.001	.003	56	.002	.022	56	0.9	5.4	56	0.2	0.5	56	.05	.36
1984	56	.001	.005	56	.002	.027	56	1.3	9.9	56	0.2	0.6	56	.07	.59
1985	58	.001	.009	58	.001	.026	58	1.4	5.4	58	0.1	0.4	58	.09	.43
29085															
1982	49	.001	.004	45	.003	.033	46	1.1	14.0	47	0.3	1.1	49	.06	.59
1983	57	.001	.007	57	.001	.035	57	1.1	13.5	57	0.2	1.2	57	.06	.60
1984	58	.001	.007	58	.001	.034	58	1.1	9.5	58	0.2	0.8	58	.06	.68
1985	57	.001	.003	57	.001	.084	57	0.8	9.7	57	0.1	0.5	57	.06	.39

TABLE 3c CONSTITUENTS IN SUSPENDED PARTICULATE (ug/m^3)

	Criterion: 2.0(24 Hours)			Criterion: 2.0 (24 Hours)								
	NICKEL			VANADIUM			NITRATE			SULPHATE		
Station and Year	# of Samples	Geo. Mean	Max.	# of Samples	Geo. Mean	Max.	# of Samples	Geo. Mean	Max.	# of Samples	Geo. Mean	Max.
29001												
1982	55	.002	.021	55	.01	.03	53	4.1	12.1	53	9.6	39.3
1983	55	.002	.030	55	.00	.03	55	3.4	19.7	55	9.3	48.3
1984	57	.005	.049	57	.00	.04	57	4.2	16.6	57	10.7	35.8
1985	57	.002	.015	57	.00	.04	57	3.1	10.0	57	6.9	16.2
29008/29102												
1982	330	.003	.055	331	.01	.04	334	4.0	16.4	334	11.4	38.5
1983	315	.002	.112	337	.00	.07	337	3.5	23.0	337	11.0	49.0
1984	51	.004	.043	51	.00	.04	50	4.2	27.2	50	11.6	35.1
1985*	52	.003	.022	52	.00	.03	37	2.8	16.6	37	8.4	19.4
29011												
1982	57	.005	.042	57	.01	.05	56	4.0	13.9	57	11.2	53.4
1983	48	.004	.018	54	.01	.02	54	3.3	17.2	54	10.9	26.3
1984	59	.006	.024	59	.01	.04	58	3.6	19.6	58	11.7	33.8
1985	58	.004	.026	58	.00	.05	58	4.1	19.3	58	10.7	26.0
29012												
1982	59	.004	.026	59	.01	.04	59	4.6	15.8	59	9.1	39.2
1983	46	.003	.024	52	.00	.02	52	3.8	21.1	52	10.0	19.8
1984	57	.003	.149	57	.00	.05	57	4.1	18.0	57	9.6	36.4
1985	58	.002	.059	58	.00	.03	57	4.3	14.9	57	9.2	21.7

*29008 moved to 29102 in 1985.

TABLE 3c CONSTITUENTS IN SUSPENDED PARTICULATE (ug/m^3)

Criterion: 2.0(24 Hours) Criterion: 2.0(24 Hours)

Station and Year	NICKEL # of Samples	NICKEL Geo. Mean	NICKEL Max.	VANADIUM # of Samples	VANADIUM Geo. Mean	VANADIUM Max.	NITRATE # of Samples	NITRATE Geo. Mean	NITRATE Max.	SULPHATE # of Samples	SULPHATE Geo. Mean	SULPHATE Max.
29017												
1982	59	.006	.032	59	.01	.04	59	4.3	16.0	59	10.2	38.7
1983	47	.006	.037	56	.00	.05	56	3.8	18.5	56	10.0	24.2
1984	57	.007	.066	57	.00	.03	58	4.0	18.1	58	11.0	24.7
1985	57	.004	.021	57	.00	.03	58	3.2	11.2	58	6.6	17.6
29025												
1982	325	.006	.068	325	.01	.08	337	3.7	20.5	337	9.6	59.3
1983	328	.004	.041	328	.00	.04	328	3.7	21.6	328	10.1	31.8
1984	57	.005	.028	57	.00	.03	57	3.4	16.4	57	10.4	35.1
1985	51	.006	.040	51	.00	.04	52	3.3	14.7	52	8.4	18.9
29067												
1982	45	.006	.023	45	.01	.04						
1983	56	.002	.015	54	.00	.03						
1984	56	.005	.031	56	.00	.02						
1985	58	.004	.039	58	.00	.03						
29085												
1982	49	.002	.024	49	.00	.03	50	3.6	13.2	50	9.4	35.6
1983	57	.001	.013	56	.00	.05	57	2.8	15.1	57	8.5	24.9
1984	58	.001	.030	58	.00	.03	58	3.2	14.3	58	8.4	28.5
1985	57	.001	.018	57	.00	.03	57	2.6	8.7	57	6.0	19.3
29087												
1982							58	4.0	17.1	58	10.3	41.1
1983							57	2.9	16.2	57	8.8	20.8
1984							55	3.0	15.8	55	8.8	26.8
1985							56	3.0	11.3	56	7.3	20.4

TABLE 3d

CARBON CONTENTS IN SUSPENDED PARTICULATES (ug/m^3) - 1985

Station	No. of Samples	TOTAL CARBON		ELEMENTAL CARBON		CARBONATE (CO_3)	
		Geo. Mean	Max.	Geo. Mean	Max.	Geo. Mean	Max.
29011 Burlington/Leeds	58	13.7	35.2	5.0	18.1	1.3	11.3
29025 Barton/Sanford	51	9.1	20.1	3.4	11.9	0.6	3.7
29085 Mountain Police	55	5.9	18.9	1.8	8.9	0.4	2.5
29102 Beach Blvd.	52	9.4	27.5	3.4	14.0	0.4	2.2

TABLE 4

SOILING INDEX

1-HOUR TELEMETERED INSTRUMENTS

UNITS - COH's per 1000 linear ft. of air

Ontario Objectives - 24-hour - 1.0
1-year - 0.5

		Annual Average	Maximum 24-hour	No. of Times Above Objective 24-hour
29001 - Hughson/Hunter	1985	.48	1.6	6
	1984	.60[9]	2.4	18
29008 - North Park	1985	.39	1.2	3
29102 Beach Blvd.	1984*	.71	1.7	79
	1983	.54	1.6	34
29025 - Barton/Sanford	1985	.52	1.6	10
	1984	.55	2.4	25
	1983	.44	1.8	13
29105 - Nash/Kentley	1985	.33	1.0	0
29118 - Main W./Hwy. 403	1985	.42[4]	1.1	3

9 - Numerical exponent refers to number of months sampled when less than 12.
* - 29008 moved to 29102 in October 1984.

TABLE 5

DUSTFALL 1984-85

UNITS - GRAMS/SQ. METRE/30 DAYS

Ontario Objectives - 1 month avg - 7.0
1 year ave - 4.5

	Annual Average			Maximum		Number of Months Above Objective	
	1983	1984	1985	1984	1985	1984	1985
29001 Hughson/Hunter	5.5	6.8	8.0	19.6	24.0	5	5
29006 Queenston	4.4	4.9	6.3	12.3	10.4	2	3
29008 North Park	9.8	11.6	-	17.2	-	12	-
29009 Kenilworth	4.3	5.9	5.7	21.7	14.3	2	1
29010 Burlington/Ottawa	22.7	21.0	16.9	34.0	22.3	12	12
29011 Burlington/Leeds	12.6	14.0	12.5	19.3	20.3	11	10
29012 Burlington/Wellington	9.3	9.8	9.5	19.4	13.7	8	9
29017 Chatham/Frid	8.1	9.9	8.8	22.9	13.3	8	7
29025 Barton/Sanford	6.8	7.2	6.2	14.1	10.4	6	4
29030 Camden/Mohawk	4.7	5.7	5.0	9.8	8.6	3	1
29031 Concession/Upper Sherman	7.9	8.0	7.7	19.1	10.1	5	8
29036 Roosevelt/Beach Rd.	15.1	17.4	16.7	36.0	24.5	12	12
29044 Wark/Beach Blvd.	8.7	8.4	8.6	13.4	15.3	8	9
29082 Leaside Rd.	7.0	8.0	7.0	16.0	11.6	6	5
29084 Rembe/Beach Blvd.	7.8	9.6	10.9	17.6	25.0	7	11
29102 Beach Blvd.	-	-	6.1	-	11.9	-	1

TABLE 6

SULPHUR DIOXIDE

UNITS - PARTS PER MILLION

Ontario Objectives: 1-hour - .25
24-hour - .10
1-year - .02

		Annual Average	Maximum 1-hour	Maximum 24-hour	No. of Times Above Objective 1-hour	No. of Times Above Objective 24-hour
29008 - North Park/ 29102 - Beach Blvd.	1985	.011	.12	.06	0	0
	1984*	.015	.13	.07	0	0
	1983	.012	.11	.06	0	0
	1982	.010	.17	.05	0	0
29025 - Barton/ Sanford	1985	.009	.11	.06	0	0
	1984	.015	.18	.07	0	0
	1983	.014	.15	.04	0	0
	1982	.014	.18	.05	0	0
29105 - Nash/ Kentley	1985	.004	.16	.02	0	0
29118 - Main W./ Hwy. 403	1985	.005[6]	.06	.03	0	0

* - 29008 moved to 29102 in October 1984.
6 - Six months of sampling (July - December).

TABLE 7

TOTAL REDUCED SULPHUR

UNITS - PARTS PER BILLION

Ontario Objective: 1-hour - 20 (Hydrogen Sulphide)

		Annual Average	Maximum	No. of Times Above Objective
29008 - North Park/ 29102 - Beach Blvd.	1985	1.0	37	15
	1984*	0.9	41	9
	1983	1.2	30	9
	1982	2.1	122	49
29025 - Barton/ Sanford	1985	1.4	56	16
	1984	1.8	44	20
	1983	1.4	48	30
	1982	1.2	111	32

*29008 moved to 29102 in October 1984.

TABLE 8

CARBON MONOXIDE

UNITS - PARTS PER MILLION

Ontario Objective: 1-hour - 30
8-hour - 13

		Annual Average	Maximum 1-hour	Maximum 8-hour	No. of Times Above Objective 1-hour	No. of Times Above Objective 8-hour
29008 - North Park/ 29102 - Beach Blvd	1985	0.3	7	3	0	0
	1984*	0.3	5	2	0	0
29025 - Barton/ Sanford	1985	1.2	10	4	0	0
	1984	0.8	16	6	0	0
	1983	0.9	12	6	0	0
	1982	1.1	10	5	0	0

*29008 moved to 29102 in October 1984.

TABLE 9

NITROGEN DIOXIDE

UNITS - PARTS PER MILLION

Ontario Objectives: 1-hour - .20
24-hour - .10

		Annual Average	Maximum 1-hour	Maximum 24-hour	No. of Times Above Objective 1-hour	No. of Times Above Objective 24-hour
29008 - North Park/ 29102 - Beach Blvd.	1985	.023	.08	.06	0	0
	1984*	.026	.09	.07	0	0
	1983	.026	.14	.07	0	0
	1982	.025	.10	.07	0	0
29025 - Barton/ Sanford	1985	.025	.11	.06	0	0
	1984	.029	.13	.06	0	0
	1983	.029	.10	.08	0	0
	1982	.031	.11	.08	0	0
29118 - Main W./ Hwy. 403	1985	.019[6]	.08	.04	0	0

* - 29008 moved to 29102 in October 1984.
6 - Six months of sampling (July - December).

TABLE 10

NITRIC OXIDE

UNITS - PARTS PER MILLION

		Annual Average	Maximum 1-hour	Maximum 24-hour
29008 - North Park/ 29102 - Beach Blvd.	1985	.020	.51	.09
	1984*	.056	.52	.22
	1983	.057	.53	.21
	1982	.052	.59	.19
29025 - Barton/ Sanford	1985	.019	.51	.11
	1984	.013	.41	.12
	1983	.018	.45	.17
	1982	.024	.44	.16
29118 - Main W./ Hwy. 403	1985	.033[6]	.92	.15

* - 29008 moved to 29102 in October 1984.
6 - Six months of sampling (July - December).

TABLE 11

OZONE

UNITS - PARTS PER BILLION

Ontario Objective: 1-hour - 80

		Annual Average	Maximum - 1 hour	No. of Hours Above Objective
29025 - Barton/ Sanford	1985	19.0	96	17
	1984	18.1	95	7
	1983	18.7	111	61
	1982	16.9	88	4
29105 - Nash/ Kentley	1985	23.0[11]	104	23
29118 - Main W./ Hwy. 403	1985	17.9[6]	99	23

11 - Numeric exponent refers to number of months sampled when less than 12.

TABLE 12

FLUORIDATION RATE - 1984-85

ALL VALUES IN MICROGRAMS/100 SQ. CM/30 DAYS

Ontario Criteria - April 15 to October 15 - 40
October 16 to April 14 - 80

	Annual Average			Maximum		Number of Months Above Objective	
	1983	1984	1985	1984	1985	1984	1985
29001 Hughson/Hunter	38	34	26	106	39	1	0
29012 Burlington/Wellington	33	22	25	33	44	0	0
29025 Barton/Sanford	52	56	34	135	69	3	1
29054 Beach Rd./Conrad	53	48	35	102	50	5	3
29058 Q.E.W./Skyway	105	85	72	144	126	7	8
29059 Burlington/Gage	84	63	51	119	76	6	5
29062 Briarwood School/ King St. E.	45	55	44	83	79	6	2
29066 Killarney/Beach Blvd.	61	50	45	85	68	5	3

APPENDIX 1

Phytotoxicology Assessment Survey in the Hamilton Area, 1985

Air Resources Branch
Phytotoxicology Section

By: Dr. W. D. McIlveen

Date: August 1986

ARB No.: ARB-058-86-Phyto

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Phytotoxicology Assessment Survey in the Hamilton Area, 1985

Introduction

Since 1970, the Phytotoxicology Section of the Ontario Ministry of the Environment has conducted annual surveys of vegetation and soils in the Hamilton area. The purpose of these surveys has been to document the condition of vegetation species and their accumulation of airborne contaminants emitted from the steel manufacturing complex located on the south shore of Hamilton Harbour. The present report summarizes the results obtained from the survey conducted in 1985 in relation to earlier investigations.

Survey Outline

The survey in its present format was established in 1973. At that time, eleven permanent sampling stations were established as indicated in Table A. These are also shown in Figure 1.

On August 14, 1985, at each established station (except Station 3) foliar samples of silver maple (Acer saccharinum) were collected for chemical analysis. Visual observations of foliage condition were also made at this time.

The samples were brought to the Phytotoxicology laboratory for processing. Each sample was divided into two portions, one of which was washed to remove surface particulate. The samples were then oven-dried, ground in a Wiley-mill and stored in glass bottles. They were then analyzed for fluoride, boron, iron and lead. In addition the unwashed samples were analyzed for sulphur, sodium and chloride. All analyses were performed by the Inorganic Trace Contaminants Section of the Ministry of the Environment Laboratory, Resources Road, Toronto.

Table A

Station No.	Location	Direction*
1	Beach Blvd. at Burlington Canal	4.4 km NE
2	Beach Blvd. at Renfrew	3.5 km NE
3	Beach Blvd. at former toll booth	3.4 km E
4	Mead and Dunn Streets	5.0 km SE
5	Craigmiller and Rosslyn Streets	2.3 km S
6	Burlington and Gage Streets	1.3 km S
7	Minto and Bristol Streets	2.3 km SW
8	Eastwood Park	3.2 km W
9	Charlton and Dundurn	7.2 km SW
10	Oakwood Place	9.3 km SW
11	West and Baldwin	12.2 km SW

* Distance and direction from approximate centre of steel making complex

Visual Observations

Injury to the maple foliage in 1985 was restricted to trace terminal necrosis typical of fluoride injury at Stations 5, 6 and 7 which are the three stations near to the steel complex. Surficial particulate was conspicious on foliage collected at Stations 5 and 6.

Chemical Analyses Results

The results of the chemical analyses are presented in Tables 1 to 6. In addition, certain data are presented in Figures 2 to 4. These latter data were based on mean values for selected two or three year intervals which could be compared with 1985 values to determine trends with time. The data are from Stations 6 to 11 which lie at increasing distances in a westerly direction from the steel mill complex. The pattern for each element is discussed within its respective section below.

Fluoride

Fluoride concentrations in silver maple foliage collected at the sampling stations are shown in Table 1. Prior to 1985, elevated fluoride values (35 ug/g F) were regularly encountered at many stations. Those stations nearest

the steel mills contained the highest amounts of fluoride. Unwashed foliage samples collected at Station 6 exceeded the limit for background concentrations for fluoride in every year since 1973. The remote stations (Stations 9, 10 and 11) all showed background fluoride values except Station 9 in 1977.

The years of higher values included 1976, 1977 and 1979 and to a lesser extent 1973. The highest value measured was 335 ug/g F in the unwashed sample collected in 1977 at Station 6. By contrast the highest value found in 1985 was 70 ug/g F at this same station. Further, this was the only station where the background concentration was exceeded in 1985.

Washed samples contained lower amounts of fluoride than unwashed samples in the majority of cases. This indicates that a portion of the fluoride was present only on the surface of the foliage and could be removed by washing. The proportion that was external to the leaf was highly variable from sample to sample; however, the data for 1985 suggests that approximately one half of the fluoride was external to the leaf, at least in those areas most affected by the steel mills.

In Figure 2, the data show a clear trend to decreasing fluoride concentrations with distance from the steel mills. At most stations, the highest fluoride concentrations were recorded in the 1976 to 1978 period. The values measured in 1985 indicate that the fluoride concentrations have continued to decline.

Boron

The concentrations of boron measured in the samples are presented in Table 2. In the past, the upper limit of background concentration (175 ppm) was exceeded only at Stations 5 and 6 which lie nearest to the steel mills. In 1985, these stations still showed the highest boron content in the samples (130 and 110 ug/g B respectively); however, they were within the normal range for vegetation in an urban area. The highest boron values of 309 and 290 ug/g were measured at Stations 5 (1975) and 6 (1977) respectively.

Boron concentrations tended to fluctuate strongly from year to year, especially at the sites nearest the steel mills. In general, concentrations tended to decrease with time although the 1985 values for Stations 4 and 9 have increased as compared with recent years. The general decrease with time is indicated in Figure 3. This figure also shows the decrease in boron concentrations with increasing distance from the source.

Iron

The iron contents of the maple foliage samples are indicated in Table 3. The data show that the foliage contained above normal (1000 ug/g Fe) consistently at Station 6 located nearest to the steel mill complex. The value of 2800 ug/g Fe recorded in 1985 was exceeded only once (1980, this station) in the study area. Above background values were recorded at Stations 2, 5 and 7 in 1977 and 1979, at Station 8 in 1977 and at Station 3 in 1977, 1978, 1979, 1982 and 1984.

The information presented in Figure 4 shows that there was a decrease in iron concentration with distance from the steel mills. The apparent trend to lower iron concentrations with time was broken by a slight increase in values in 1985 as compared with recent years at all stations.

Lead

The lead content of vegetation is shown in Table 4. Since 1980, no samples of maple foliage collected in the Hamilton area contained lead in concentrations considered to be above that of urban background (60 ppm). Up to 1980, elevated lead levels were found at Stations 2, 3 and 6 on two or more occasions. Lead values found in 1985 were essentially unchanged from previous years at corresponding locations. At Station 6, located nearest to the steel mill, the lead values were higher than at the remaining stations.

Sulphur

The sulphur concentrations in the silver maple foliage are presented in Table 5. The concentrations varied widely from year to year at any given station. The highest value of 0.4% sulphur at Station 6 in 1981 equalled the upper concentration limit for urban background situations. This same location also contributed the highest sulphur value recorded in 1985 (0.24% S). No other pattern of sulphur content with respect to time or locations could be determined.

Zinc

The zinc content of maple foliage is summarized in Table 6. All values measured were well within the normal range (250 ug/g Zn) except in 1979 at Station 6. Station 6 consistently gave the highest zinc measurements of any of the stations thus suggesting some contribution from air borne emissions from the steel mills. The concentrations of zinc measured in 1985 were generally similar to those measured in recent years but were usually lower than those encountered in the early years of the survey.

Salt

The principal components of road salt (sodium and chloride) in foliage are shown in Table 7. Although the highest chloride value of 0.68% was found at Station 6, this does not hold true for sodium. A pattern of salt components in vegetation which could be attributed to the steel mill complex was not apparent.

Summary

The annual surveillance program to determine whether emissions from the steel mill complex at Hamilton were affecting vegetation was continued in 1985. From the results obtained, it was shown that fluoride, boron and iron values were elevated in proximity to the steel mill and decreased with distance, thereby implicating the steel mills as a source(s) of these elements. Fluoride and iron exceeded background values in 1985 at only one station located closest to the steel mills. In general, the fluoride and boron (at most sites) values continued to decline in 1985 but at the same time, iron concentrations were higher than in recent years. Lead, sulphur, zinc, sodium and chloride values were all well within their respective normal concentration ranges although the concentrations of these elements were frequently highest near the steel mill complex. Lead and zinc concentrations have generally decreased during the time frame of the surveys carried out in the Hamilton area.

PH65/25

Table 1. Fluoride concentrations (ug/g, dry wt.) in not washed (NW) and washed(W) silver maple foliage collected in Hamilton, 1973-1985

Station No.	Location* km	1973		1974		1975		1976		1977		1978		1979		1980		1981		1982		1983		1984		1985	
		NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W
1	4.4 NE	32	22	23	15	19	16	114	52	35	27	21	16	56	50	28	22	23	18	22	10	20	15	29	21	28	15
2	3.5 NE	130	75	32	43	32	29	96	56	97	68	29	24	112	89	45	28	29	31	51	42	15	16	23	21	21	10
3	3.4 NE	330	175	61	55	67	53	273	132	179	115	75	59	222	161	67	35	36	29	61	12	34	21	37	26	-	-
4	5.0 SE	80	45	30	16	26	14	107	49	37	25	20	14	49	28	32	15	25	16	40	22	14	9	21	17	23	12
5	2.3 S	65	42	68	58	29	21	141	77	110	63	46	22	106	77	22	10	38	37	42	30	26	28	28	22	24	15
6	1.3 S	177	107	181	140	92	80	243	146	335	191	111	60	203	107	164	135	91	59	42	30	120	48	71	54	70	33
7	2.3 SW	52	55	72	41	42	38	110	51	141	66	55	27	88	62	32	18	40	29	62	50	61	16	24	16	26	13
8	3.2 W	45	35	35	16	38	32	46	23	73	45	48	22	49	41	15	18	28	22	36	48	17	8	14	12	21	10
9	7.2 SW	17	15	21	13	13	11	31	19	40	26	14	11	30	22	10	5	23	16	20	26	11	10	13	11	7	6
10	9.3 SW	15	12	12	7	3	23	15	7	12	8	9	8	21	14	3	3	22	14	18	10	6	5	9	9	5	4
11	12.2 SW	15	15	13	9	-	-	26	16	31	24	6	5	16	14	5	3	10	8	12	12	6	5	9	8	4	2

Contaminant Guideline: Foliage, NW - 35 ppm fluoride

**Relative to center of steel-making complex.*

Table 2. Boron concentrations (ug/g, dry weight) in not washed (NW) and washed (W) silver maple foliage collected in Hamilton, 1973-1985

Station No.	Location* km	1973		1974		1975		1976		1977		1978		1979		1980		1981		1982		1983		1984		1985	
		NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W
1	4.4 NE	113	138	93	91	108	99	107	103	139	127	83	82	120	118	91	78	81	81	66	66	51	42	50	44	48	44
2	3.5 NE	106	106	92	103	94	91	82	77	-	-	82	55	70	72	76	74	64	66	46	61	46	45	67	75	54	55
3	3.4 E	136	136	113	113	82	78	95	77	110	110	71	73	87	78	72	94	70	71	65	55	62	38	75	70	-	-
4	5.0 SE	82	77	69	65	75	66	63	63	85	78	75	75	53	57	59	58	58	54	46	37	48	44	55	59	56	53
5	2.3 S	118	118	124	117	309	283	200	166	-	-	239	213	109	110	131	138	119	130	125	120	150	123	96	105	130	120
6	1.3 S	158	153	139	138	179	161	174	177	290	273	163	155	230	222	138	168	186	187	246	194	217	186	275	193	110	120
7	2.3 SW	148	128	111	109	154	143	116	104	125	112	107	117	125	111	156	163	128	124	104	108	104	149	127	90	70	72
8	3.2 W	60	59	79	78	81	75	71	73	78	73	54	53	45	38	57	67	106	84	88	89	84	66	89	82	72	25
9	7.2 SW	84	80	79	85	90	87	74	70	78	77	90	53	66	68	82	86	60	68	47	42	51	55	42	41	67	71
10	9.3 SW	50	50	63	55	61	56	65	57	46	39	44	44	62	59	49	42	36	38	39	46	42	42	50	51	40	38
11	12.2 SW	74	75	62	55	-	-	76	69	97	87	39	39	48	50	63	63	41	40	50	49	45	40	64	62	40	37

Contaminant Guideline: Foliage, NW - 175 ppm boron

* *Relative to centre of steel-making complex.*

Table 3. Iron concentrations (ug/g, dry weight) in not washed (NW) and washed (W) silver maple foliage collected in Hamilton, in 1977-1985

Station No.	Location* km	1977		1978		1979		1980		1981		1982		1983		1984		1985	
		NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W
1	4.4 NE	670	440	512	357	987	847	585	680	424	270	566	412	596	307	700	360	950	580
2	3.5 NE	1390	690	518	415	1110	870	780	555	711	505	679	560	438	319	640	440	690	430
3	3.4 E	1840	1410	1010	780	2117	1330	970	755	841	425	1160	456	987	623	1040	550	-	-
4	5.0 SE	620	383	395	303	743	547	715	435	489	325	423	260	377	269	410	270	630	490
5	2.3 S	1200	467	458	206	1030	757	435	240	587	360	368	229	510	227	320	230	550	360
6	1.3 S	2370	1840	1370	910	2467	1600	3500	2380	2020	1020	2100	1200	1760	1180	2400	1030	2800	2000
7	2.3 SW	1700	730	502	237	1066	837	690	410	880	375	682	540	450	213	450	190	680	410
8	3.2 W	1130	750	558	333	977	803	610	565	628	415	685	528	522	253	340	220	540	180
9	7.2 SW	630	350	190	110	480	306	260	160	224	135	416	284	199	181	220	170	300	200
10	9.3 SW	350	183	165	115	340	213	430	430	94	70	159	140	120	88	180	130	210	170
11	12.2 SW	403	217	160	92	397	313	200	180	137	90	104	98	151	76	130	110	200	160

Contaminant Guideline: Foliage, NW - 1000 ppm iron

** Relative to centre of steel-making complex.*

Table 4. Lead concentrations (ug/g, dry weight) in not washed (NW) and washed (W) silver maple foliage collected in Hamilton 1973-1985

Station No.	Location* km	1973		1974		1975		1976		1977		1978		1979		1980		1981		1982		1983		1984		1985	
		NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W
1	4.4 NE	22	15	20	13	9	8	32	23	19	16	15	11	20	18	14	14	10	6	12	10	13	11	13	7	13	8
2	3.5 NE	72	47	61	40	21	16	46	34	49	31	26	21	42	40	14	14	20	8	15	11	10	10	10	7	11	7
3	3.4 E	272	201	57	47	34	25	75	62	53	39	33	21	32	26	14	11	20	9	18	11	17	15	13	7	-	-
4	5.0 SE	55	31	38	21	19	13	42	26	25	19	16	13	50	30	14	12	14	6	12	8	12	13	11	7	13	10
5	2.3 S	35	24	35	31	11	7	27	23	33	20	20	11	24	20	12	7	13	10	11	8	8	9	8	6	10	7
6	1.3 S	79	65	103	72	72	54	86	62	129	87	43	32	67	41	64	43	23	10	30	20	22	23	26	16	32	25
7	2.3 SW	41	31	38	27	7	4	30	24	40	22	16	9	28	20	12	9	15	7	13	10	8	8	8	3	9	6
8	3.2 W	50	46	40	29	21	13	38	29	35	23	30	24	32	26	18	18	16	9	14	12	8	9	6	4	7	5
9	7.2 SW	26	26	25	14	5	2	29	22	24	19	24	9	18	13	10	10	6	4	11	7	6	8	7	5	6	3
10	9.3 SW	21	27	24	16	4	2	27	15	17	12	8	6	13	11	6	6	3	2	6	4	5	8	3	2	3	2
11	12.2 SW	27	19	20	14	-	-	28	18	21	14	10	7	21	17	11	11	6	4	5	5	7	9	5	3	4	4

Contaminant Guideline: Foliage, NW - 60 ppm lead

* *Relative to centre of steel-making complex.*

Table 5. Sulphur concentrations (% dry wt.) in not washed (NW) and washed) silver maple foliage collected in Hamilton, 1978-1985

Station	Location*	1978		1979		1980		1981		1982		1983		1984		1985
		NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW
1	4.4 NE	0.17	0.17	0.29	0.28	0.18	0.18	0.2	0.2	0.2	0.19	0.14	0.13	0.15	0.14	.18
2	3.5 NE	0.13	0.13	0.19	0.19	0.16	0.14	0.2	0.2	0.13	0.15	0.12	0.13	0.13	0.12	.19
3	3.4 E	0.24	0.26	0.31	0.31	0.21	0.21	0.2	0.2	0.26	0.19	0.19	0.19	0.22	0.16	-
4	5.0 SE	0.21	0.20	0.23	0.21	0.20	0.17	0.2	0.2	0.19	0.20	0.18	0.18	0.20	0.21	.22
5	2.3 S	0.24	0.21	0.20	0.19	0.16	0.15	0.2	0.2	0.17	0.15	0.17	0.14	0.12	0.12	.15
6.	1.3 S	0.21	0.22	0.29	0.30	0.26	0.26	0.4	0.4	0.39	0.27	0.25	0.23	0.25	0.22	.24
7	2.3 W	0.27	0.26	0.29	0.25	0.20	0.19	0.2	0.2	0.20	0.23	0.19	0.21	0.16	0.17	.15
8	3.2 W	0.17	0.16	0.22	0.21	0.17	0.18	0.2	0.2	0.23	0.20	0.18	0.16	0.20	0.17	.16
9	7.2 SW	0.23	0.22	0.25	0.21	0.21	0.22	0.2	0.2	0.25	0.22	0.15	0.15	0.10	0.08	.22
10	9.3 SW	0.17	0.17	0.21	0.22	0.20	0.19	0.2	0.1	0.18	0.19	0.15	0.16	0.16	0.16	.19
11	12.2 SW	0.11	0.11	0.20	0.18	0.15	0.16	0.1	0.1	0.15	0.15	0.13	0.13	0.13	0.11	.15

Contaminant Guideline: Foliage, NW - 0.4%

* Relative to center of steel-making complex.

Table 6. Zinc concentrations (ug/g dry wt.) in not washed (NW) and washed (W) silver maple foliage collected in Hamilton, 1973-1985

Station No.	Location* km	1973		1974		1975		1976		1977		1978		1979		1980		1981		1982		1983		1984		1985	
		NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W
1	4.4 NE	91	50	51	48	45	43	68	54	50	44	47	52	52	49	50	50	31	30	38	37	42	38	36	34	68	80
2	3.5 NE	121	117	96	80	118	114	101	80	58	48	61	54	77	84	98	92	83	84	54	61	47	46	71	71	84	92
3	3.4 E	123	112	116	92	116	103	141	132	121	108	140	133	175	159	102	100	81	75	106	66	85	90	90	84	-	-
4	5.0 SE	81	65	48	39	30	24	55	40	58	51	58	53	67	60	76	66	59	63	55	48	44	49	60	67	64	82
5	2.3 S	91	55	109	102	38	31	71	62	69	52	48	39	76	71	64	55	62	64	51	45	52	53	46	47	47	59
6	1.3 S	170	150	195	175	102	80	193	145	247	222	168	154	317	251	172	147	102	84	113	80	123	118	115	110	140	130
7	2.3 SW	125	93	75	75	85	44	96	70	101	83	61	49	75	66	58	50	50	40	45	38	52	53	65	40	46	39
8	3.2 W	93	82	67	54	80	69	72	56	77	59	58	50	78	75	50	48	60	63	59	59	41	37	45	37	45	11
9	7.2 SW	56	54	60	60	62	54	75	63	69	78	54	57	48	42	70	75	47	41	40	32	38	42	25	24	52	50
10	9.3 SW	59	69	60	60	66	59	75	67	53	47	57	60	43	41	52	50	45	40	40	49	40	48	68	65	46	56
11	12.2 SW	69	69	53	40	-	-	91	71	73	65	38	34	56	53	73	80	41	39	55	53	50	50	67	56	44	47

Contaminant Guideline: Foliage, NW - 250 ppm zinc

* *Relative to center of steel making complex.*

Table 7

Concentrations of sodium and chloride in
silver maple foliage collected in Hamilton, 1985

Station	Location	Element	
		Sodium (ug/g)	Chloride (%)
1	4.4 NE	200	.36
2	3.5 NE	61	.21
4	5.0 SE	44	.14
5	2.3 S	44	.28
6	1.3 S	130	.68
7	2.3 SW	64	.46
8	3.2 W	130	.12
9	7.2 SW	32	.29
10	9.3 SW	24	.06
11	12.2 SE	17	.19

Contaminant Guideline Foliage NW - Sodium 350 ug/g
Chloride 0.85%

Figure 1 Vegetation monitoring stations in the Hamilton area

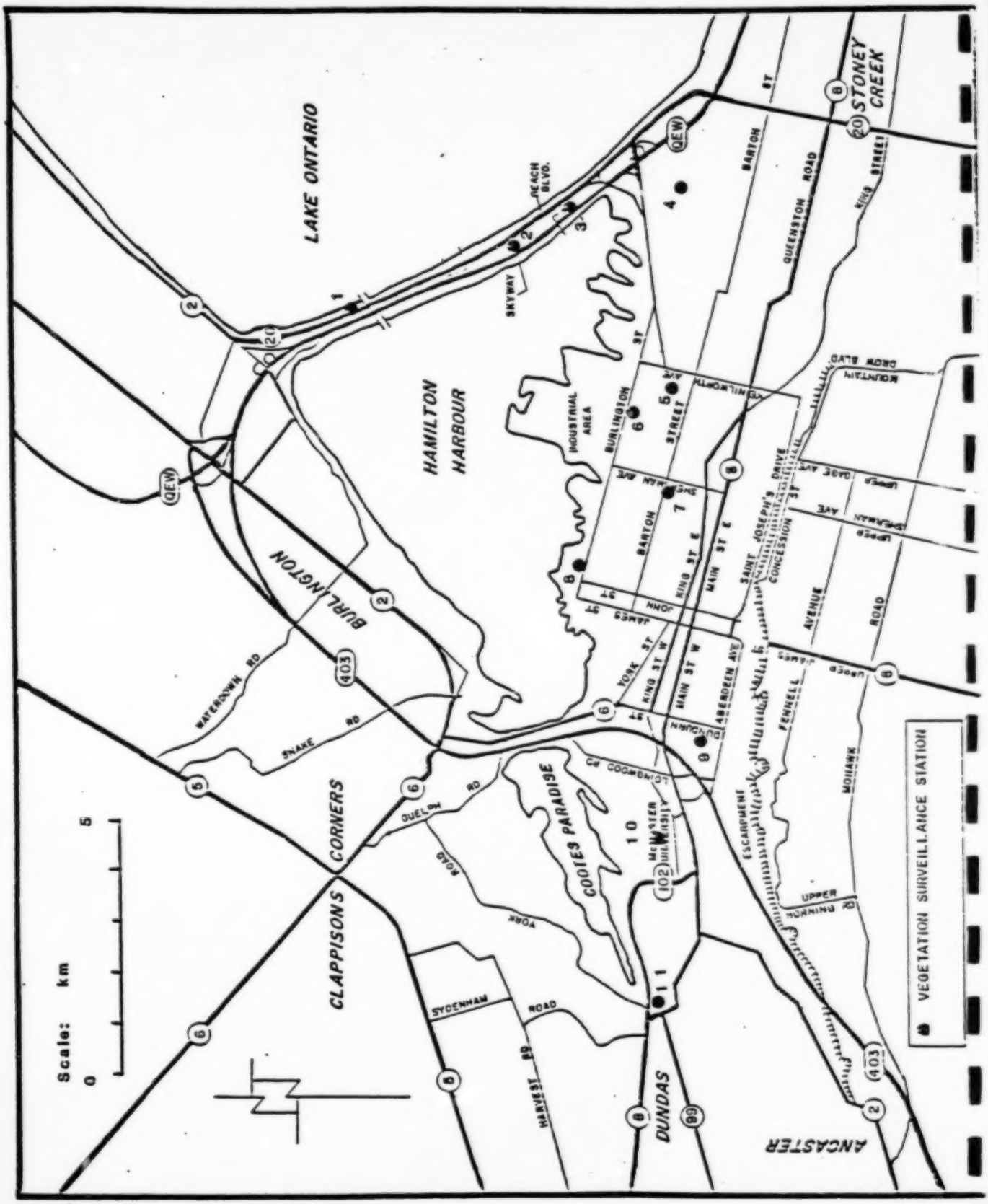

Figure 2

Concentration of Fluoride
in Silver Maple Foliage
Hamilton Survey

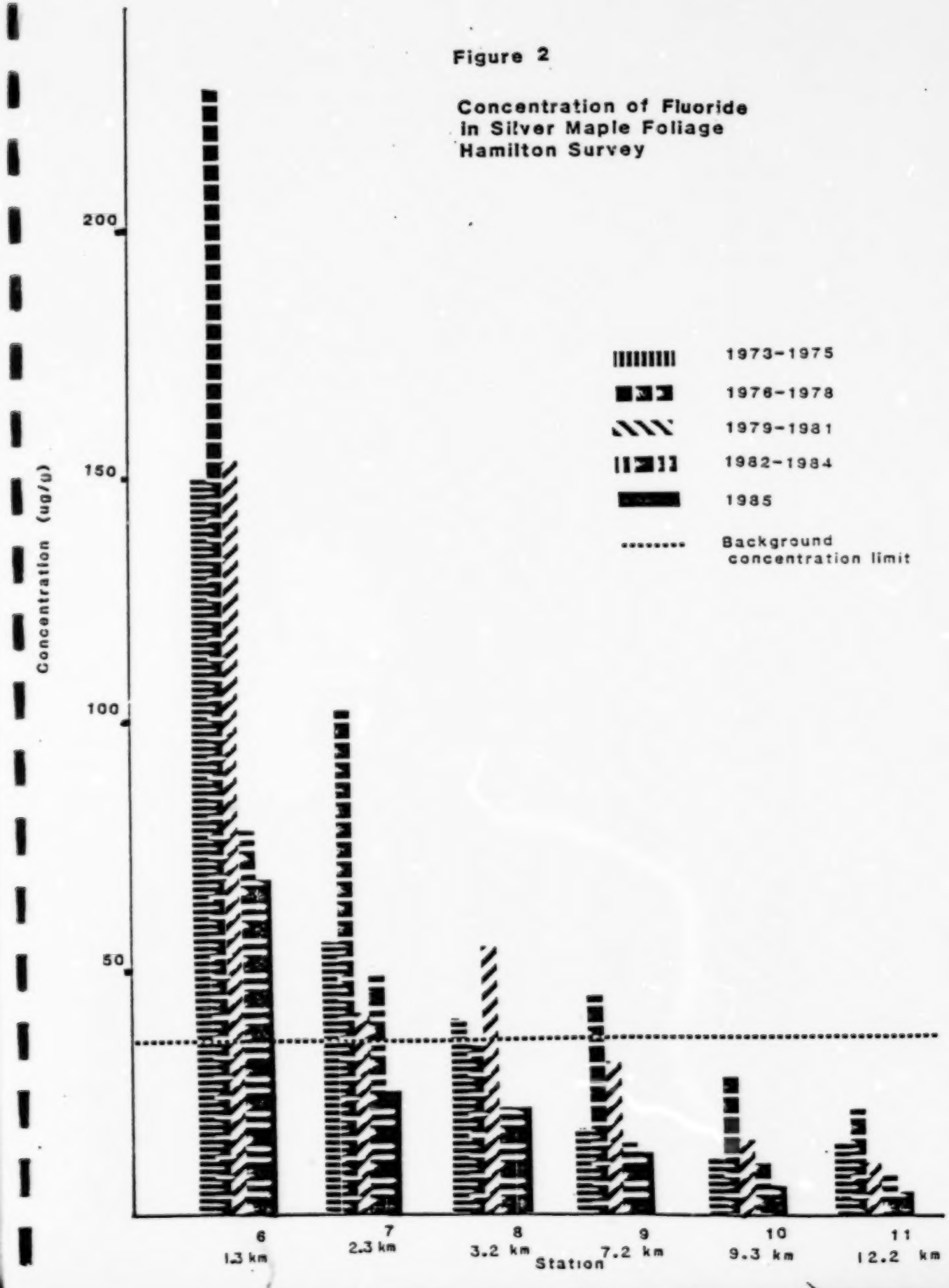

Figure 3

Concentration of Boron
In Silver Maple Foliage
Hamilton Survey

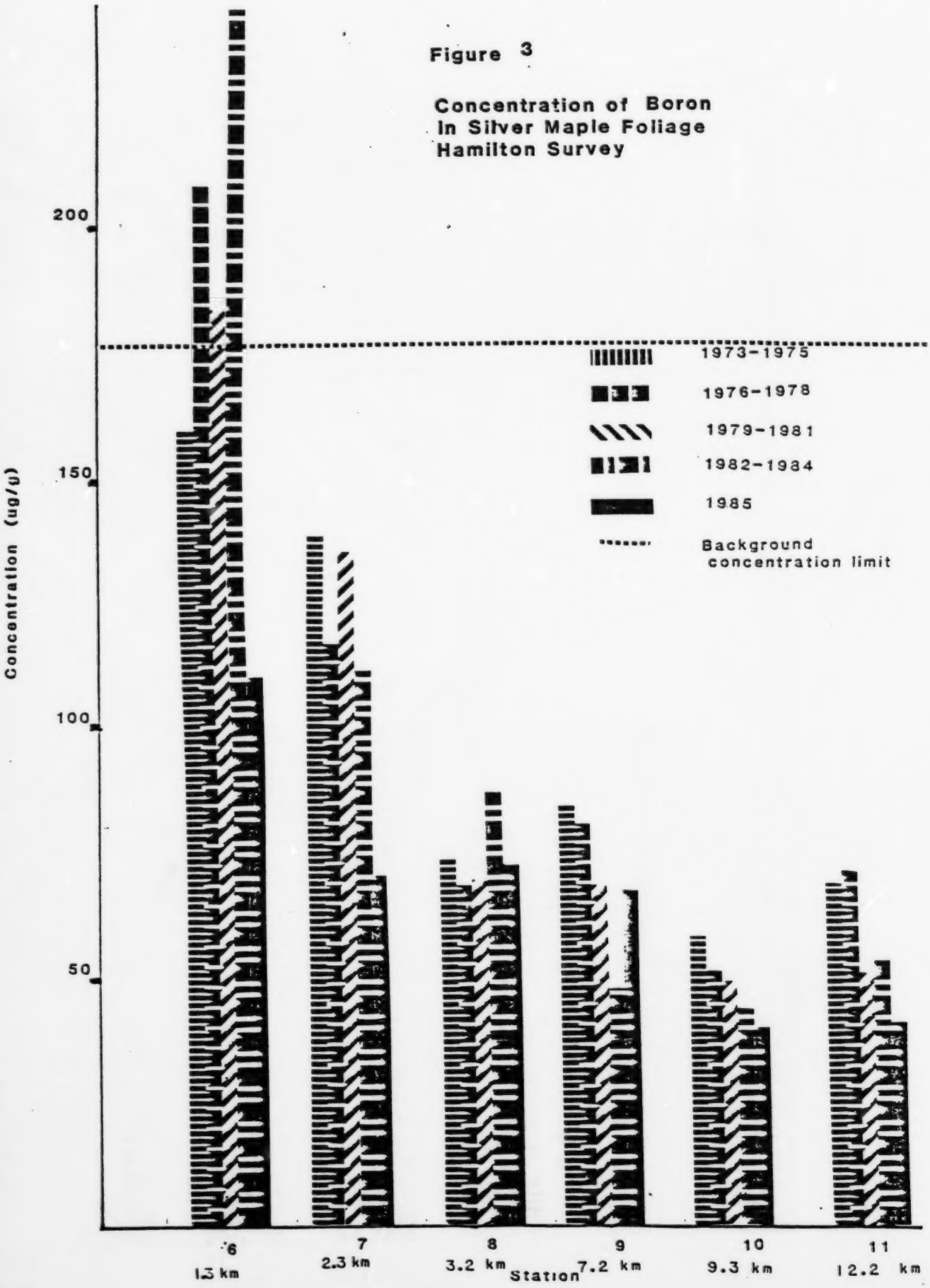

Figure 4

Concentration of Iron in Silver Maple Foliage Hamilton Survey